TSTAR Workshop X

Mitigating the Effects of Exotic Pests on Trade and Agriculture

Part A. *the Caribbean*

Campbell Agricultural Center
Homestead, Florida
June 16-18, 1999

T-STAR WORKSHOPS

	1984
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	1986
II	Symposium for Tropical/Subtropical Agriculture Research
	1987
III	Forage-Livestock Workshop
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IV	Alternative Agricultural Enterprises for the Caribbean and Pacific Basins
	1991
V	Important Arthropod Pests of the Caribbean Basin Amenable to Biological Control: Homoptera, Coleoptera, and Lepidoptera
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VI	Environmental Stress Workshop
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VII	Agroecosystems Sustainability in the Caribbean and Pacific Island Economies
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Frontispiece. Central America and the Caribbean
Map from CIA World Factbook,
<http://www.odci.gov/cia/publications/factbook/ref.html>,
accessed January 12, 2000.

T•STAR Workshop X

Mitigating the Effects of Exotic Pests on Trade and Agriculture

Part A. The Caribbean

Proceedings of a workshop held at

Campbell Agricultural Center
Homestead, Florida
June 16-18, 1999

Sponsored by

T•STAR — Tropical and Subtropical Agriculture Research
Cooperative State Research, Education, and Extension Service
United States Department of Agriculture

Waldemar Klassen
Workshop Chair

T-STAR *A Special Grant of the USDA CSREES*
Tropical & Subtropical Agriculture Research

The T-STAR program, Tropical and Subtropical Agriculture Research, is funded by Special Research Grants (under Public Law 89-106) from the Cooperative State Research, Education, and Extension Service (CSREES), United States Department of Agriculture. The program is designed to strengthen the research capabilities and economy of the United States' tropical-subtropical areas in the Caribbean and Pacific Basins. Much of the research conducted in the temperate United States is not applicable to these areas due to the large differences in climate, soils, crops, insects, and diseases, as well as socio-economic constraints. Challenges include: continuing plant disease pressure in the year-round growing season, control of alien pests and weeds in Caribbean and Pacific Island agroecosystems and adjacent natural ecosystems, and post-harvest processing to extend shelf-life and preserve quality. Opportunities include: new germplasm collection, maintenance, breeding, and genetic engineering for novel products, value-added processing and marketing of tropical crops, and restoration and maintenance of healthy agroecosystems. Regional agricultural research is critical to meeting the increasing challenges and opportunities in tropical island environments.

Program Goals

- Provide research that maintains and enhances production of established tropical and subtropical agricultural products.
- Develop agricultural practices in the tropics and subtropics that are environmentally acceptable through an agroecosystems approach.
- Enhance the role of value-added agriculture in tropical island ecosystems.
- Expand and diversify presently unexploited food and fiber products which have potential for commercial production in the U.S. tropical and subtropical regions.
- Expand tropical and subtropical agriculture's linkages to related industries and economic sectors.

Participating Universities

Caribbean Basin Administrative Group

- University of Florida
- University of Puerto Rico
- University of the Virgin Islands

Research goals and objectives for the T-STAR program are set forth in a Strategic Plan developed jointly by T-STAR-Caribbean and T-STAR-Pacific. The objectives of individual research projects are targeted toward the goals and objectives of the Strategic Plan. In T-STAR-Caribbean, individual research projects relate directly to the interests of Caribbean agriculture, including some of its impacts on continental U.S. agriculture.

To learn more, visit the T-STAR Web site:

http://www2.ctahr.hawaii.edu/t-star/T-STAR

The Technical Committee

- **Dr. John Neilson**, Assistant Dean for Research, University of Florida
- **Dr. Rafael Davila**, Dean/Director, University of Puerto Rico
- **Dr. James Rakocy**, Director, University of the Virgin Islands
- **Dr. Thomas Helms**, Executive Director, Southern Association of Agricultural Experiment Station Directors
- **Dr. J. Preston Jones**, Interim Program manager, USDA/CSREES, Washington, D.C.
- **Dr. Richard Mayer**, USDA/ARS Director, U.S. Horticulture Research Laboratory, Orlando, Florida
- **Mr. Dean F. Davis**, Program Manager for the Caribbean Basin Group, P.O. Box 110490, University of Florida, Gainesville, Florida. Mr. Davis coordinates and implements Committee decisions.

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Preface

Waldemar Klassen

Director, Tropical Research and Education Center, University of Florida
Homestead, Florida

In December, 1994, the Summit of the Americas was held in Miami, Florida. Among the Summit's many results was the goal of establishing a free-trade area of the Americas by the year 2005. Whether this will be accomplished remains to be seen, but imagine that all the Western Hemisphere is one free-trade area.

Regardless of what happens officially, globalization of trade and tourism continues to accelerate. The door to the rapid growth in agricultural trade, of course, was opened by the Uruguay Round and by the General Agreement on Tariffs and Trade (GATT). The Uruguay Round addressed both technical and nontechnical barriers to agricultural trade, and included a Sanitary/Phytosanitary agreement (SPS), which requires that all phytosanitary standards and policies have to be scientifically based and justified by transparent risk assessments. This SPS agreement stipulates that quarantines and other phytosanitary measures can be used only to protect against the risk of pests. Quarantines and phytosanitary standards can't be used just to exclude someone else's products.

In addition to the SPS, 107 countries have signed the International Plant Protection Convention. This convention is administered by the Food and Agriculture Organization of the United Nations (FAO). There's a secretariat associated with this convention which develops international standards for phytosanitary measures. These standards are considered authoritative by the World Trade Organization (WTO) when it adjudicates trade disputes under the GATT.

Given the new realities of international trade, this workshop addresses two imperatives that are relevant to the Caribbean basin. The first is to increase trade in a manner that's beneficial to the economies of the basin. And since trade may create pathways whereby dangerous exotic pests may enter a country or enter the basin, we have a second imperative, and that is to mitigate both the risk and the effects of those pests that actually do make it through our quarantines and get established. The purpose of this workshop is to identify specific problems that may be solved through economic or biological research or a combination of these. To that end, we have provided for several panels that will meet and try to pull together some of the research imperatives.

This workshop is the latest in a series sponsored by T-STAR, which stands for Tropical-Subtropical Agriculture Research, and it is a consortium of American universities in the Pacific basin and in the Caribbean basin that conducts research aimed at improving the well-being of people in those two basins. The U.S. Congress funds T-STAR at about $3 million a year, divided equally between the Caribbean and Pacific basins. T-STAR is administered by the Cooperative State Research, Education, and Extension Service (CSREES), a branch of the USDA. T-STAR is functionally divided into two administrative groups: the Caribbean Basin Administrative Group (T-STAR-Caribbean) and the Pacific Basin Administrative Group (T-STAR-Pacific).

T-STAR-Caribbean draws together efforts of researchers form the University of the Virgin Islands (UVI), the University of Puerto Rico (UPR), and the University of Florida (UF). Currently, T-STAR-Caribbean is chaired by Dr. James Rakocy (UVI). UPR is represented by Dean/Director Rafael Davila, and UF is represented by Dean/Director Richard Jones. Representing USDA-CSREES and USDA-ARS are Drs. J. Preston Jones and Richard Mayer, respectively. Program manager for T-STAR-Caribbean is Dean F. Davis, who implements and administers decisions of the Technical Committee composed of university and agency representatives.

Planning for this workshop began over a year ago. We had meetings and discussions with representatives from each of the universities and U.S. federal and Florida state agencies. Specifically, I'd like to acknowledge: Carol Harper, Rosa Franqui, Emilio Hernandez, all from Puerto Rico; Mike Shannon from APHIS; Ken Vick and Jennifer Sharpe from ARS; and Connie Rieherd from FDACS. From the University of Florida we had Dick Berenovski, Jorge Peña, Randy Ploetz, John VanSickle, and Charles Brown.

Staff from the University of Florida's Tropical Research and Education Center (TREC) worked very hard to make the workshop a success — before, during, and after the event. Thanks go to Marie Thorp, Maria Delgado, Kelly Sullivan, Brian Sheahan, and Harry Trapper. Ian Maguire was the photographer.

I'd also like to thank Don Pybas and staff at the Miami-Dade Cooperative Extension Service from making an excellent facility available to us.

Lastly, I'd like to thank the speakers and participants for making the workshop a significant gathering. Many countries were represented — St. Lucia, Trinidad, Bermuda, Chile, the U.S., and Brazil, among others. Their valuable contributions are found in the following pages.

Waldemar Klassen
October 1999

Challenges in Safeguarding Florida and the U.S. against Invasive Pests

Mike Shannon
Director, APHIS-PPQ Florida Division
Gainesville, Florida

These remarks are my attempt to describe the problem that invasive indigenous species pose to the political and ecological community described as the "Caribbean Basin" and to suggest a more strategic approach to addressing it. While these problems tend to be framed and attacked on an individual basis by each political jurisdiction, they impact the entire ecology, social structure, and economy of the region. As such, they would be more effectively attacked with our collective resources as the collective priority they really are.

Herein lies the relevance to the Tropical and Subtropical Research initiative in providing a forum for focusing science and research directed to the prevention, detection, and management of key invasive species threats. This is the key outcome needed from this conference.

As a member of the Caribbean Basin ecological community, the state of Florida, with its $6 billion agricultural industry, is presently faced with a tremendous amount of pressure from exotic pest introductions conveyed by international commerce. Florida receives 80 percent of all propagative plant material and 70 percent of all cut flowers imported into the United States. The port of Miami is the third largest cargo port in the world, and it is estimated that over 70 million passengers will pass through Miami by the year 2010. In addition, 70 percent of passengers traveling between the United States, the Caribbean, and Latin America pass through Miami.

Florida's proximity to the Caribbean makes it especially vulnerable to exotic pest introductions. This high risk pathway has been realized year after year with repeated detections of exotic pests that make their way from the Caribbean islands to Florida's shores. We have witnessed the introduction and establishment of the Diaprepes Weevil, Black Parlatoria Scale, Brown Citrus Aphid, Tomato Yellow Leaf Curl Virus, a Geminivirus complex with associated whiteflies, and variety of thrips and scale insects. We are now facing the imminent introdution of Pink Hibiscus Mealybug, Stellate Scale, and damaging sugarcane and citrus root weevils, Africanized honeybee, Bont tick, Swine fever, and Giant African Snail — to name a few.

More invaders are poised to attack the Caribbean ecosystem — Medfly, Carambola Fly, Citrus Greening Disease, etc.

It is readily apparent that current inspection, detection, and eradication efforts are inadequate to address the increasing volume of international trade and associated pests. In managing the repeated outbreaks of exotic pests, Florida has had to incur an enormous financial and social burden and deal with increasing environmental and public concerns. In addition, the introductions of these damaging pests compromise our efforts in facilitating exports with our trading partners who are equally concerned about these pest species. Florida can be viewed as a beach-head for exotic pest threats to the rest of the U.S., both as a key entryway for imported goods destined to other areas and as a place where nonindigenous species first establish on the continent.

The United States has in place a program funded at over $100 million to identify and control the risks associated with international trade. These funds are obtained through user fees assessed to passengers and carriers and must be used for port-of-entry–related activities. This pest exclusion network is neither infallible nor impermeable and some exotic organisms gain entry in spite of our best efforts.

Accepting this fact, national systems for managing the risks from invasive species must include appropriate detection, eradication, and management activities in order to fulfill their mandates. The capacity to avoid and manage these problems is dependent upon scientific knowledge and technology.

Other Caribbean Basin members also have such systems with varying degrees of capacity, depending on the resources and priorities of each sovereign nation.

The basic components for a National Safeguarding System are as follows:

- Prevention— regulatory restrictions (permits, prohibitions, etc.) that prevent risk at point of origin
- Entry Interdiction — control of entry at point of arrival of passengers, cargo, carriers and application of appropriate mitigative actions
- Detection — formal programs in place focused on early location of key invaders
- Eradication — elimination of infestations where it is technically, economically, socially, and environmentally feasible
- Management — development and transfer of technology to live with invasive species that cannot be eradicated.

The key issue in the process is to accept that prevention and point-of-entry interdiction are far from infallible, although empirically they can be demonstrated to have significant impact on the problem. If there were not border controls, there is little question our problems would be much worse.

The term "Caribbean Basin" has been defined in many ways on political, sociological, and economic bases. However, all of these definitions tend to divide us in managing this problem. When one looks closely at the history of invasive species problems, it is clear that we are joined in our vulnerability to the economic, social, and environmental impacts of invasive species. The problem that confronts us is:

- Intense trade, agricultural production linkages, and geographic proximity facilitate the spread of invasive species within the community
- Invasions by highly disruptive organisms of many types appear to be increasing
- With some exceptions, individual political entities act independently to exclude, detect, and manage invasives.

Speaking as a public servant, it does not appear to be most effective for the public interest to continue addressing these shared threats to our common ecosystems on an individual, country-by-country basis. Coping with the emergence of the globalization of trade requires an international coalition that apparently does not exist at this time. What may be needed is development of a Caribbean basin safeguarding strategy that would include the following components:

- Identify the nature and significance of invasives in the "Basin"
- Identify key external biological threats to "Basin" ecosystems
- Build public and private coalitions around those problems
- Establish equivalent risk management and safeguarding systems among "Basin" members
- Establish appropriate surveillance strategies for key organisms
- Provide enhanced scientific and research support on high priority invasive issues.

The capacity to manage this problem is absolutely dependent on sound science and technology that is transferable to the problem. The above strategy is meant to provide a context that can maximize the possibility of this happening.

The next question is how and where will the leadership for such a strategy emerge.

Florida Agriculture: Domestic and International Business Climate/Demographics

John R. Gordon, William A. Messina, Jr., Daniel J. Cantliffe, Roger D. Newton, Fritz M. Roka, Marilyn E. "Mickie" Swisher, John J. VanSickle[a]

presented by William A. Messina, Jr.

Executive Summary

Florida's farm people, natural resources, technology, and economic and political conditions have combined to produce a large, complex agricultural industry that will continue to be an important component of the state's economy in the decade ahead. The future of Florida agriculture will be heavily influenced by drivers of change including conditions in the general economy, growth and change in the composition of population, the global nature of agriculture and trade, government policies and regulations, natural resource and environmental issues and technology development.

Some likely implications of these drivers of change include the following trends:

1 Access and ability to utilize biotechnologies, information technologies and new production and processing technologies appear to be critical factors of success for operating in the business climate of the future. Computerized information technologies will create a demand for specialized knowledge on how to use the information in successful farming operations.

2 The operating environment of the future will be characterized by increased risks.

3 The domestic market for agricultural products will continue to grow slowly as U.S. population and income growth will support only modest increases in aggregate demand for food products. Continued increases in demand for convenience foods and dining out are anticipated.

4 Continued rapid population growth will further intensify competition for Florida's vital natural resources. Few other states will feel these trends as intensely as Florida.

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a J.R. Gordon, Prof. and Chair, Dept. Food and Resource Economics; W.A. Messina, Jr., Executive Coordinator, Int'l Agricultural Trade and Development Center, Dept. Food and Resource Economics; D.J. Cantliffe, Prof. and Chair, Dept. Horticultural Sciences; R.D. Newton, Extension Agent, Environmental Horticulture, Hillsborough Co.; F.M. Roka, Assistant Prof., Southwest Florida Research and Education Center, Immokalee; M.E. Swisher, Assoc. Prof., Dept. Family, Youth and Community Sciences; and John VanSickle, Prof., Dept. Food and Resource Economics; all University of Florida.

5 Over the longer term, world population increases and economic growth will expand international markets for farm products. The United States is likely to become increasingly important in world agricultural trade, but this role is not assured unless U.S. agriculture is extremely competitive in future export markets. For Florida agriculture, changes resulting from FTAA (Free-Trade Area of the Americas) and GATT/WTO (General Agreement on Tariffs and Trade/World Trade Organization) negotiations and in trading relationships with Cuba could be particularly important.

6 Potential exists for new economic opportunities from embracing environmental objectives.

Because of market competition, agriculture is increasingly thought to be transforming to a global agricultural/food industry structure which is unlike the dispersed family farm system of the past. While transformation to this worldwide structure is not certain, at least parts of this scenario are likely to characterize the food industry of the 21st century.

The future of Florida agriculture will be heavily influenced by the drivers of change discussed in this paper. Other forces of change may also be important. To survive and thrive, Florida agriculture will need to compete in markets which are increasingly global and to be compatible with the needs of a rapidly urbanizing state. There are uncertainties and challenges ahead, but there will also be opportunities for Florida agriculture in the new millennium.

I. Introduction

Florida's agriculture owes its unique character and viability to the abilities of its farm people, the quantity and quality of its natural resources, the development of suitable technologies, and a business and political climate conducive to agricultural growth and development. While there have been many obstacles to overcome, these attributes have combined to allow Florida's agriculture to develop from rather meager beginnings with a system that would feed and clothe at most about 200,000 people to the modern industry it is today. With a farm population of less than one percent of the total, Florida agriculture provides fruit, vegetable, animal, and other agricultural products that now supply millions of people in markets throughout the world. Florida and U.S. citizens are rightfully proud of state and national agricultural industries which have given consumers high quality, abundant food supplies for a lower percentage of consumer income than any other country in the history of the world.

This record of success has not been easily achieved. Historically, managers of agricultural and related food businesses have been required to anticipate and react to a constantly changing array of economic, biological, and physical challenges. For example, the energy crisis of the 1970s, the freezes of the 1980s, and international trade agreements of the 1990s have had major impacts on Florida agriculture.

The primary purpose of this paper is to identify and improve understanding of the major forces or trends occurring in society which will influence the future of agriculture, natural and human resources in Florida as we enter the new millennium. These major forces or "drivers of change" are important because of the influence they will have on future decisions about agriculture, natural and human resources in our state. The specific objectives of this paper are to: (1) identify and highlight the major trends or drivers of change which will impact U.S. agriculture in the years

ahead; (2) discuss the nature of the changes which might be expected over the next several years; and (3) explore the implications of these changes for Florida agriculture and its natural and human resources.

Not surprisingly, many of the important drivers of change in the past also will be influential in shaping Florida agriculture, natural and human resources during the coming ten to twenty years. However, the particular set of forces influencing the production, marketing, and consumption of food and fiber products in the future will be different from past experiences. Florida agriculture will be increasingly influenced by a complex and closely interrelated set of world, national, state and local factors and events which will impact in ways which are not always obvious or easy to anticipate.

A logical ordering of the discussion is difficult as the important drivers of change have much interdependency and are overlapping. Major drivers identified are discussed under the topics of General Economy, Population Trends, Global Nature of Agriculture and Trade, Government Policies and Regulations, Natural Resource and Environmental Issues, and Technology Development.

Further complicating this analysis is the fact that Florida's agriculture is more diverse than that of most any state in our nation, with over 250 crop and livestock commodities produced commercially. While these commodity subsectors may share common interests in general agriculture issues, they can also be quite different from one another. Each commodity industry therefore may be affected quite differently by the drivers of change. For example, vegetable growers may experience very different effects from trade agreements than dairy producers. Individuals with a special interest in a particular commodity are urged to reflect on implications of the likely changes in the context of their specific commodity.

II. Trends/Drivers of Change

General Economy

Agriculture is one of the economy's basic sectors. Conditions in the general economy have important implications for agriculture, and economic conditions in agriculture affect the rest of the economy. Over time, the interrelationships of agriculture with the general economy have increased with important but sometimes difficult-to-understand consequences.

Key indicators of the general economy are growth in gross domestic product (GDP) and rates of inflation, interest, and unemployment. These indicators are important because they influence the real income of consumers and, consequently, the demand for agricultural products. They also have important effects on farm input costs. Various macroeconomic or monetary and fiscal policies are utilized by government to influence these barometers of the general economy.

Macroeconomic policies of the federal government in the 1980s were an important prelude to the 1990s. Prominent among the policies of the early 1980s was the determination of the Federal Reserve Board to reduce inflation. This decision reversed a succession of earlier policies which had contributed to very high rates of inflation. A second significant policy decision of the early 1980s was reflected in tax cuts which sharply reduced federal government revenues. When combined with the failure to significantly reduce spending, unprecedented budget deficits were assured.

The economic environment of the 1980s which resulted from these policies was characterized by a reduction in inflation rates, high real interest rates (actual interest rate less the rate of inflation), a strong dollar in international markets, and large federal deficits. In the early 1990s, the federal government increased taxes and made efforts to restrict spending. Monetary policy has been restrictive enough to avoid raising inflationary concerns but lax enough to encourage some growth in the U.S. economy. This combination of policies has resulted in modest expansion of the economy combined with low unemployment, interest, and inflation rates. The federal budget has recently turned from deficit to surplus, and additional surpluses are projected. This record of accomplishment has been realized and maintained despite the fact that many countries in Asia and South America are presently experiencing severe financial crises and recession. Partly as a consequence of this situation, the United States continues to experience a substantial trade deficit.

Although the overall U.S. economy has continued to grow, impacts on specific economic sectors have been varied. For agriculture, which is both capital intensive and export sensitive, the results have included recent reductions in agricultural exports (from a peak of over $60 billion in 1996 to an estimated $52 billion in 1999), and many commodity prices have been very low. Low citrus and vegetable prices in the 1990s have resulted in substantial decreases in some Florida agricultural land values. On the other hand, costs of many purchased inputs such as fuel, fertilizer, feed, and interest rates paid for borrowed capital have also been reduced because of the competitive economy and low inflation rates.

The Federal Reserve Board appears determined to keep inflation in check. With favorable inflation rates, modest growth rates and projected federal budget surpluses, the dominant concern in the general economy is the prospect that weaknesses in the economies of other countries will spill over into this country. Otherwise, although growth will not be constant, the longer term outlook for the general U.S. economy appears bright and continued GDP growth rates of 2–4 percent a year appear possible. Unemployment rates could be nudged lower because large numbers of women have been absorbed into the labor force. Thus, the overall rate of growth of the labor force is likely to be slowing.

Population Trends

Population is a major determinant of demand for agricultural products. Annual per capita food consumption in this country has been fairly stable for several years. Growth in U.S. population clearly would be expected to increase the demand for food. Population is an important factor in other ways as well. A growing population competes with agriculture and forestry for use of natural resources. Changing demographic characteristics also can have important implications for tastes and preferences and hence consumption patterns for various food products.

World population was an estimated 5.0 billion in 1987 and is projected to be 6.0 billion in 2000. Most of the population increases are occurring in the less developed countries. Many of these countries have a serious need for food products, but because of extremely low per capita incomes there is limited means for them to purchase products in the markets. It is important that these countries develop their economies so that they will have additional income to purchase food products in the world markets in order to avoid worsening nutritional conditions.

Generally accepted predictions of population numbers in the United States indicate gradual but continued small increases. Demographers are predicting average annual population increases of about 0.8 percent for the United States during the next twenty years. U.S. population is therefore expected to increase from 275 million in 2000 to about 298 million in 2010 and 323 million in 2020. Florida's population is expected to increase at a rate two to three times that of the nation as a whole; from 15.4 million in 2000 to 17.8 million in 2010 and 20.3 million people in the year 2020 at which time Florida is predicted to be the third most populous state, behind only California and Texas. These projections reflect a net increase of over 650 people per day in the state of Florida during the next twenty years.

Important demographic changes also are anticipated in both the United States in general and Florida in particular. The proportion of the U.S. population younger than 44 years of age will decline, while older age groups will be proportionately larger. These age structure shifts will be particularly dramatic in Florida. Florida is the only state with more than 18 percent of its existing population 65 years of age or older. No other state exceeds 16 percent of seniors. The leading edge of the baby boom generation will be 55 years old in 2001. The impact of this generation of Americans has been dramatic at all of its age levels. Although crime rates are down, a negative public image of crime in south Florida may continue to encourage growth in central and northern areas of the state. All areas of the state, however, are expected to experience continued population increases with existing heavily populated areas receiving the largest number of new residents.

Global Nature of Agriculture and Trade

U.S. and Florida agriculture have experienced increasing integration with the world economy. This internationalization of U.S. agriculture has brought increasing dependence on foreign trade for product markets and sources of supply of important raw materials. Although, in general, increased trade is felt to be in agriculture's interest there can be widely differing impacts depending on the commodity and terms of trade.

In 1999, the ninth Round of multilateral trade negotiations under the GATT/WTO (General Agreement on Tariffs and Trade/World Trade Organization) are scheduled to begin. This is significant for agricultural sectors in countries throughout the world because agricultural programs will be a focus for this Round of negotiations as they were in the previous Uruguay Round. Preliminary indications are that the final agreements under the upcoming Round of negotiations will undoubtedly represent another significant step toward the globalization of world agricultural production and trade.

At the same time, trade liberalization is high on the agenda of governments throughout the Western Hemisphere as a result of commitments to have a Free-Trade Area of the Americas (FTAA) in place by the year 2005. Policy adjustments which will be required under the FTAA are likely to dramatically influence and significantly realign competitive structures for all industries and business sectors throughout the hemisphere. To the extent that the liberalization process which took place under the North American Free-Trade Agreement (NAFTA) is an indicator, both challenges and opportunities can be expected to arise for U.S. agriculture as a result of implementation of the FTAA.

Because the FTAA will include Brazil (the world's largest citrus producer and one of the world's largest sugar producers) and a number of other countries which are significant fruit and vegetable producers (such as Chile), Florida's agricultural sector, in particular, needs to be prepared for the potential competitive challenges that await. However, agricultural interests in the state also should be on the lookout for possible new market opportunities which may arise from the counter-seasonal nature of agricultural production patterns in North and South America.

Still, another potential policy issue of importance is related to U.S. policy toward Cuba. Because of the geographic proximity of Florida, the striking similarity of their traditional agricultural production patterns, and undeniable historical and cultural ties, a resumption of trade and commercial relations between the United States and Cuba, whenever it may occur, will have important implications for the agricultural sector in Florida. Moreover, given the extensive volume of agricultural trade between the two countries prior to the imposition of the U.S. embargo in 1960, many opportunities also can be anticipated for U.S. agriculture when the embargo is lifted. While no one knows when such a change may take place, Florida and U.S. agriculture need to be prepared for such an eventuality.

Government Policies and Regulations

Public policies reflect the ways that citizens and elected officials wish to improve upon the outcomes of the market. Accumulation of supplies of agricultural products and low farm income have in the past brought forth attempts by the federal government to improve the economic situation of farmers. Such intervention has occurred through attempts to restrict supplies, increase demand or by direct support of farm income. Historically, much of Florida's agriculture — citrus, vegetables, and ornamentals — has not been affected by the mainstream agricultural commodity programs. Peanuts, tobacco, sugar, and dairy are commodities produced in Florida that have been affected by these programs. The 1996 Farm Bill was intended by Congress and the Administration to phase out traditional price and income support features of U.S. agriculture programs that have evolved from the Agricultural Adjustment Act of 1933. Future agricultural policies are expected to continue the philosophy of a smaller government role in commodity programs.

Farming in the United States continues to undergo significant structural adjustments and farm size distribution and saving-the-family-farm concerns arise periodically as political issues. Estimates indicate that more than 75 percent of U.S. farms rely heavily on off-farm income to provide financial support for the farm and lifestyle for the family. While these structural difficulties are not likely to be completely ignored, U.S. society and policy makers have never been willing to commit to policies which significantly influence the long-run trends toward fewer and larger farms.

In recent years, a large number of regulations, laws, rules, ordinances, and restrictions have been developed to achieve goals and objectives often related to the environment or worker health and safety which are generally considered desirable by society. These regulations can impact significantly on Florida agriculture — often with unintended consequences. The number of regulatory agencies has also proliferated. More than thirty county, state, and federal agencies regulate the production of food and fiber in the state. Meeting the requirements of these regulatory agencies ranks high among farmers as a

constraint on production as regulatory pressures add to production costs, thereby diminishing the competitive position of Florida producers. Because of the complexity of the regulations, farmers frequently hire technical consultants to assist them in meeting the requirements.

Consumers have long held strong interest in food price policies which result in low, but stable, food prices. They are also interested in issues related to nutrition, food safety, and food quality. Growth in consumption of fruits and vegetables has been credited to the increased interest of consumers in healthier diets. Per capita consumption of selected vegetables and melons increased 23 percent from 1976 to 1996. Increased demand for quality is evidenced in a 38 percent increase in per capita use of fresh vegetables during that same time period.

Interest in food safety is evident in the increased demand for Country of Origin labeling. Consumers are interested in safer foods and the assurances provided because U.S. producers are required to follow regulations intended to produce safer food. Interests in Country of Origin labeling on the part of producers are the result of increased regulations on U.S. producers relative to other global producers to produce safe food and the need to be able to differentiate their product in the market to communicate that safety to consumers. The recently enacted Food Quality Protection Act is an effort on the part of policy makers to assure the safety of domestically produced food.

Florida farmers will continue to find that nonagricultural programs and regulations emanating from agencies other than the USDA will have significant impacts on farm operations. Environmental regulations, foreign policies, monetary policies, transportation regulations, land use policies, etc., are examples of such government activity.

Natural Resource and Environmental Issues

Agriculture is heavily influenced by the natural resource base. Florida's climate, soils, water, forests, and unique ecosystems are vitally important to the state's agriculture, but they also contribute to the attractiveness of the state for uses which compete with agriculture. Population projections indicate that these competing pressures will only increase during the next ten to twenty years.

Large acreage of Florida's farmland is being converted to urban uses, although the exact amount lost each year is difficult to determine. Occasionally, the loss of agricultural land in Florida is raised as an issue of concern. However, with adequate supplies of food items in stores and downward pressure on farm prices and incomes, many farmers are more concerned about maintaining their option to sell or use their land for a purpose other than agriculture, if necessary. In many cases, it is the possible nonagricultural use of the land which supports the price of the land and allows the farmer to borrow money.

Surface waters comprise about 18 percent of the total area of Florida. These lakes and rivers are attractive for recreational and commercial uses. In some cases, their waters are used consumptively. However, groundwater is the source for almost 90 percent of the public water supplies in Florida and is the source for about half of the water used for irrigation. Water withdrawals are replaced by infiltrating rain water in recharge areas that are increasingly being identified and protected. Competition for water is a growing concern. As potable water becomes an ever more valued resource for Florida's urbanization and

growth, the manner in which agriculture, forestry, and resource management practices affect this resource will receive even greater review and, very likely, even greater restrictions will be implemented in the future. Water conservation alone will not solve the problems. Water for irrigation purposes will become increasingly expensive, and water planning efforts will likely assign higher priority to urban requirements than to agricultural needs. Furthermore, groundwater is readily recharged by rain and surface runoff in much of the state and is easily contaminated by chemicals from spills, surface discharges, dumps, landfills, and pesticide applications. Protection of the quality of the fresh water supply is and will continue to be a major concern.

The state contains a variety of unique ecosystems. These contribute to a rich diversity of plant and animal species that are important, not only to Florida residents, but to the entire nation. Both regulatory strategies and direct purchase of such landscapes are approaches to their protection which will continue over the foreseeable future. Public policy in Florida has aggressively pursued public acquisition of environmentally sensitive land. In the last 10 years, Florida's CARL (Conservation and Recreation Lands) program alone has spent over $1 billion on acquisition of environmentally sensitive land across Florida. In Collier County, almost 70 percent of the land area is targeted for public ownership. Some of the interest and activity in protecting unique ecosystems will affect agricultural operations.

North Florida remains one of the most intensively managed forest ecosystems in the world. This is due in part to the favorable climate, soils, and topography. A more important reason for this development is the location of many wood-based primary production facilities in the Southeastern Coastal Plain. Intensive forest management, via the extensive implementation of pine monoculture, has been adopted to better capitalize on the region's long-term forest land investment opportunities.

This wealth of natural resources offers opportunities, responsibilities, and problems to Florida farmers and foresters. The very diversity and uniqueness of the ecosystem places a responsibility on managers to seek operating systems that will be economically productive without destroying the environment. Otherwise, increased regulation is assured. Florida residents have shown that they want to live in an environment free of agricultural odors and water pollution. However, the greatest threat to the resources and to the farming community comes from the influx of population from outside the state, both as tourists and as new residents. The very attractiveness of Florida resources, bringing in new people, increases the competition for the resources and make it more difficult to preserve the quality of the environment.

Technology Development

Over the last two decades, development, and adoption of new technology has been the single most important factor allowing Florida agriculture to remain competitive in the increasingly global marketplace. Technology improvements can also result in practices which are more compatible with environmental and natural resource needs.

The potential for technological advances in agriculture over the next few years is substantial. Per unit decreases in cost of production made possible by this technology will largely determine the successful agricultural enterprises. Having the best technologies will be absolutely essential to success. As other countries in the world are beginning to adopt many of these cutting-edge

technologies and as control of the research migrates from the public to the private sector, there are serious questions as to the extent to which Florida agriculture will be able to maintain its competitive position. Two major types of technology are of most interest currently, information technology and biotechnology.

Information technologies are rapidly changing the way we live and conduct business. The ability to communicate and access information instantaneously rather than in days and weeks has enormous management implications. The Internet is a major contributor to globalizing markets. Advances in remote sensing and monitoring technology will improve precision management of irrigation, drainage, fertilization, pest management, and protection from weather hazards.

Over the past decade, biotechnology research has dramatically changed the scope, direction, and intensity of agricultural research programs. This impact will continue in the future, especially initially as related to plant science. Previously, these programs were predominantly conducted under the auspices of the public sector. In recent years, however, a larger proportion of this research has been conducted by the private sector, and in many cases, public-sector research has drastically declined. Programs being supported by the private sector are selected based on profit potential, and thus, priorities of the biotech research agenda are being influenced.

Pests and pest populations continue to increase because of increases in mono-cropping, rapid resistance of various pests to control measures, globalization of markets, and environmental regulations. In order to accelerate global ability to produce crops profitably, research efforts in the area of bioengineering, marker-assisted breeding, and other areas of biotechnology have been instituted. Economic measures will increasingly be used to help justify the development of this technology and experience to this point suggests that the private sector companies funding this research will initially target those technologies with the largest potential market; i.e., row crops such as corn, soybeans, cotton, etc. For example, last year some 41 million acres, or 15 to 20 percent of total U.S. crop area was dedicated to products of biotechnology, i.e., transgenic plants. (The major products were Roundup-ready soybean, BT cotton, and BT corn.) Analysts predict that worldwide sales of agricultural biotechnology will surpass $300 billion in the next 10 years.

Conversely, while horticultural crops represent about 35 percent of the value of all crops grown in the United States, because of their relatively high value, they only utilize around 5 percent of the land devoted to crop production. Thus, when the private sector looks at their research spending priorities for these commodities, they quickly become less important. Minor crops such as the horticultural crops, which are the mainstay of the Florida agricultural industries, may or may not fit into the economic mainstream of commercial biotechnology companies.

Florida producers will feel the global change and concentration of agricultural firms which produce and sell pesticides, fertilizers, farm machinery, and seeds, now and in the future. Growers may have fewer choices and less competition among a variety of commercial vendors which may lead to problems in obtaining certain seeds of various specialty crops, as well as not being able to develop interest by large companies for solving specific problems pertaining to potentially only Florida producers. The area of enlightenment and new discovery through biotechnology, a potential major product of these large firms, might help Florida producers solve problems in both the short term and long term for which

there previously were no apparent solution. Besides increasing productivity and improved quality traits, growers might be the beneficiaries of new and improved varieties containing resistance to multiple diseases and insect pests through biotechnology.

Acceptance in the United States of crops and other products derived from biotechnology has been quite high, and thus, should not be a deterrent to the use of these technologies. Florida producers, for the most part, not only have a more diverse set of problems, but generally a more intense set of problems once they are presented. Such examples are Citrus Tristeza Virus, natural disasters from hurricanes, water and freezes, higher incidence of fungi and bacterial diseases due to conducive environmental conditions for the pathogens, and higher incidences of new diseases and new insects due to Florida's location and the movement of both people and materials in and out of the state. In the 1990s for instance, Florida not only had a new whitefly introduced, but the whitefly also carried a new Gemini Virus. More recently, Citrus Tristeza Virus was localized from area to area, tree to tree, because of the lack of virulent vectors to move the pathogens freely throughout Florida's citrus groves. Within the last two years, a new insect — the Citrus Brown Aphid — has come into Florida and has been able to vehemently vector Citrus Tristeza Virus, causing potential havoc among citrus producers. This continues to be the case of citrus canker and other diseases for which we have no cure. It is to the advantage of all of the Florida producers to accentuate the efforts related to and derived from biotechnology to solve these problems. The addition of new chemicals and strategies related to potential environmental pollutants belongs in the past, thus, it will be up to researchers to develop strategies to solve these problems without causing additional problems.

The factors which characterize Florida's agriculture as being one which produces high-value, high-cost commodities under sophisticated management are factors which also drive up the resource requirements for its agricultural science base. Also, in other parts of the country, research in one state usually has application to neighboring states. But, as previously noted, Florida produces a large number of highly specialized and unique crops, not grown in many other states. Thus, Florida's agriculture benefits less from knowledge developed elsewhere. Increasingly, these technologies are controlled by private companies with patents and licenses. Publicly supported research and educational programs will be required to assure that all sizes and types of farms understand how to utilize and adjust to the available technology.

III. Implications

Some implications of these drivers of change are cautiously offered.

1. Access and ability to utilize technology appears to be the critical factor of success for operating in the business climate of the future. In particular, firms able to capture the benefits of biotechnologies and information technologies will be the most efficient.

2. The operating environment of the future will be characterized by increased risk. The U.S. government appears less willing to offer a safety net than in the past. Managers will need to successfully deal with uncertainties from world markets, technologies, and government policies as well as biological and weather-related risks.

3. Competitive advantage in agricultural production is becoming less a function of natural factors and more a function of the

extent to which cost-effective technology is utilized. The real competitive advantages of U.S. farmers today lie in their high output per unit of labor and in the scientific and industrial infrastructure that supports agriculture production and marketing.

4 The domestic market for agricultural products will continue to grow slowly because U.S. population and income growth will support only modest increases in aggregate demand for food products. Increasing incomes and an aging population will cause further shifts in demand for food products; some of these shifts could be dramatic. Vegetables, fruits, and selected seafood and meat products may be increasingly desired. Increased consumer income and improvements in products are expected to result in continued increases in demand for convenience foods and dining out as well as for ornamental plants and foliage products.

5 Increasingly, many agricultural products compete in a national or international market and are therefore affected very little by local increases in population. However, Florida's large and rapidly growing population will offer some opportunities for specialty products that serve local markets. U-pick and roadside vegetable and fruit stands are evidence of local markets offering survival strategies or niches to some producers.

6 Continued rapid population growth will intensify competition for Florida's vital natural resources. Increased nonagricultural demand for resources will place upward pressure on water and land prices, increase pressure for stricter environmental controls on farming methods, and result in more control of state agricultural legislation by urban interests. Few other states will feel these trends as intensely as Florida. Political responses to these problems have picked up momentum dramatically from state and local government concern about growth management.

7 The potential exists for new economic opportunities from embracing environmental objectives. Some land owners are starting to capitalize on their native wildlife resources and exploring the potential of ecotourism. "Green" labels, which endorse environmentally friendly production practices, might provide Florida producers with niche marketing opportunities. Finally, as we better define the economic values of environmental resources, opportunities may develop to compensate land owners and agricultural producers directly for management practices which enhance and preserve environmental amenities.

8 Over the longer term, world population increases and economic growth will expand international markets for farm products. Protein and other desired foods will continue to increase in importance as people in developing countries upgrade their diets. All regions of the world will strive to increase their ability to produce food. Many countries with debt problems will attempt to limit import purchases. These countries are under enormous financial pressures to increase their exports and decrease imports. In addition, many countries have their own internal agriculture policies which stimulate production and protect their markets. Consequently, the United States is likely to be increasingly important in world agricultural trade, but this role is not assured unless U.S. agriculture is extremely competitive in future export markets. For Florida agriculture, changes in trading relationships with Cuba and changes

resulting from GATT/WTO and FTAA negotiations could be particularly important.

9 Computerized information technologies will create a demand for specialized knowledge on how to use the information in successful farming operations. Specialized legal, financial, marketing, and accounting services will be increasingly needed. Large farms will turn increasingly to specialized sources for information, but the vast majority of family farms will continue to rely predominantly on traditional agencies like the Extension Service and Natural Resource Conservation Service for information.

IV. Summary and Conclusions

Florida's farm people, natural resources, technology, and economic and political conditions have combined to produce a large, complex agricultural industry that will continue to be an important component of the state's economy in the next decade. The setting in which agriculture will be operating will be influenced by conditions in the general economy, growth, and change in the composition of population, the global nature of agriculture and trade, government policies and regulations, natural resource availability, and technology development. These drivers of change will cause the general setting to be somewhat different than it was in the recent past. However, the dual challenge to Florida agriculture to be increasingly cost competitive and, at the same time, be compatible with an increasingly urban Florida will be even more intense in the years ahead. Success in the compatibility area will depend on the willingness of farmers and urban interests to discuss their problems and look to new ideas and technologies for help in finding mutually acceptable compromise solutions.

Because of market competition, agriculture is increasingly thought to be transforming to a global agricultural/food industry structure which is unlike the dispersed family farm system of the past. The anticipated changes in development and ownership of technology, increases in governmental regulation, more open world markets and increased trade, increased financial risks, increased contracting and specialized market access all suggest that commercial farms will be larger and fewer in number. But, this transformation is viewed as much more than just increasing farm size. It is likely that agricultural production increasingly will be controlled by global firms that also control production and other food marketing functions throughout the world. These firms will be able to deliver food products from around the world to consumers anywhere in the world. In the global food industry, production agriculture will just be another function within a large international company that very likely controls all of the production/marketing functions from deciding what to produce all the way to the consumer. While transformation to this worldwide structure is not certain, at least parts of this scenario are likely to characterize the food industry of the 21st century.

The future of Florida agriculture will be heavily influenced by the drivers of change discussed in this paper. Other forces of change may also be important. To survive and thrive, Florida agriculture will need to compete in markets which are increasingly global and be compatible with the needs of a rapidly urbanizing state. There are uncertainties and challenges ahead, but there will be opportunities as well for Florida agriculture in the new millennium.

Critical Commodities in the Caribbean Basin: Patterns of Trade and Market Potential

Richard N. Brown, Jr.
International Agricultural Economist

Foreword

Prior to my retirement 18 months ago, I was employed by the U.S. Department of Agriculture. After 35 years of federal service as an agricultural economist in Washington, D.C., I decided to leave the government and pursue other interests. During the last 18 years of my employment, I served as the Caribbean Basin Economist for the Economic Research Service (ERS), monitoring and reporting changes in agricultural production and trade in the region. Prior to joining USDA in 1962, I studied agricultural and biological sciences at Cornell University, economics and statistics at Penn State, and institutional economics and law at the University of Wisconsin.

During the next few minutes I would like to give you an update of what my former colleagues and I learned about the agriculture of the Caribbean region after the Caribbean Basin Initiative (CBI) was enacted in 1983.

Introduction

The opening speakers have already given us several points to consider as we proceed with this workshop. During the next few minutes, I will show you how we used national and international data sets at ERS to assess the economic impacts of the Caribbean Basin Initiative in the 1980s. Then I will show you how some of the same sources were used to prepare an update for this workshop.

Although the data sets we relied on leave much to be desired, I have found them to be quite useful as proxy variables for studying agricultural production and trade changes in the Caribbean. More specifically, I think readily available data sets can help us distinguish between "high-" and "low-risk" commodities for the purposes of this workshop. So please bear with me while I make a few other introductory remarks before proceeding with my analysis and conclusions.

Although I am an international agricultural economist, I do not intend to present an econometric model or any other sophisticated methodology. We now have neither the time nor data to model many of the potential impacts generated by the continuing arrival of new pests and diseases on our shores. Indeed, some problems can best be studied with electronic models, and other speakers at this workshop will give us some examples before we go home. But our job this morning is to

identify the kinds of monitoring and research that are needed — on a continuing basis — to slow the movement of harmful pests and diseases in the entire Caribbean region.

Exotic pests or potential pests often arrive on a Caribbean island before they are identified in the United States. Frequently, this affords us time to assess potential losses that may occur if the pest is found in Florida or elsewhere. If a new arrival is identified quickly, while it is still outside the United States, then scientists like ourselves can assess potential risks, as well as develop controls — hopefully — that will minimize potential losses.

Some Conceptual Problems

The title of this session suggests I will limit my remarks to "Critical Commodities, Patterns of Trade, and Market Potential in the Caribbean Basin." But which agricultural commodities are "critical"? By whose definition are some identified as "critical" and others not? The economist's? The biologist's? The customs agent's? Think about it for a moment. How would you approach the subject?

Then there is the question of what is the "Caribbean Basin" anyway? How shall we define it? Does it refer to the islands only, or does it include other parts of North and South America as well? In many respects, it does not make any difference how we define the Caribbean Basin, because no matter how it is defined, it will be a region with a lot of water, several countries, and many islands.

Nevertheless, for statistical purposes it may make a big difference how we define it. For example, when statistical comparisons of data from different sources are undertaken, we need to know precisely which geographic entities are included and which are not, otherwise we might draw the wrong conclusions. (This is easy to do, because each agency, country, or international organization that collects and publishes statistical information on the Caribbean today, is likely to have its own unique set of definitions. Just a word of caution for now.)

Greater Caribbean Basin Defined

For this paper, I have developed a broad definition of the Caribbean Basin, which I will call the "Greater Caribbean Basin" (GCB). The GCB includes all the islands and island states in and around the Caribbean Sea, plus all the countries in Central America between Mexico on the north and Colombia on the south; plus five countries on the north shore of South America bordering the Caribbean Sea. Altogether, there are approximately 35 political entities in this region, depending on how various islands are grouped and counted (see frontispiece).

I will refer from time to time to the Caribbean Island part, or the Central American part, or the South American part. In some cases, I may even compare one country with another in the analysis.

This broad definition of the Caribbean Basin is useful for two reasons: First, it includes all the geographic land areas in the region that sooner or later will be of interest to most of us at this workshop; and second, it facilitates the standardization and use of published data for economic and statistical purposes.

Critical Commodities Defined

Honestly, I am not sure how to define "Critical Agricultural Commodities." The term has a conceptual problem because each person in this audience probably has a different concept of which commodities are "critical," whether produced, traded, or smuggled.

"Critical" appears to have time and place components, as well. For example, once a biological control is found and disseminated, our concept of what is critical may change. For a grower, any crop which provides a significant portion of his income becomes critical whenever it is threatened by a new pest or disease. For a quarantine officer, a crop becomes critical whenever it is identified as a pesky invasive species itself or a primary vector for the transmission of other nasty pests or diseases.

Rather than focus on the word "critical," let's focus instead on what has been documented concerning production, trade, and market potential of agricultural commodities which can be grown in the Basin and are potential pests themselves or are vectors of other pests when the commodity is exported to another island or country.

Background and Objectives

Over the years, I have learned that the task of assessing risks and measuring economic impacts is simplified if one knows precisely what data is available and what supplementary data are needed to improve the accuracy of any proposed analysis. Needless to say, it also helps if you know how to use — and not abuse — published data and information. But as I mentioned earlier, please be aware of all definitional differences in any published data.

Furthermore, I have found that a simple analysis often can be completed quickly by using proxy variables and deductive reasoning, even if the investigator has only limited knowledge of the subject.

For example, I live in Virginia where it sometimes freezes in winter. I also know that banana plants are susceptible to freezing temperatures. Thus, I can safely conclude that banana growers in Virginia are not going to sustain any serious economic losses from the deliberate or accidental introduction of a new virus that devastates banana production elsewhere in the hemisphere. Why? Commercial banana production is not feasible in Virginia. Similarly, I can assume that crops that do not grow well in selected areas of the GCB may be considered as low risk crops until proven otherwise.

So my assignment for this workshop, is:

- to provide an overview of the current agricultural production and trade situation in the Greater Caribbean Basin region and comment on the outlook for new developments;
- to identify sources of information that may be useful when assessing which agricultural products, produced and traded in the Caribbean Basin, are potential vectors of high risk pests to the agricultural industries of the United States and other countries in the region; and
- to provide some suggestions as to how various bits and pieces of public and private information may be used to assess the potential risk for the United States or any other country in the region, as new pests arrive and patterns of agricultural production and trade evolve.

In other words, I consider myself to be a member of a team that has been asked to identify some of the critical agricultural commodities, produced and traded in the region, that may facilitate the introduction of new exotic pests and diseases to the United States.

For example, consider the pink hibiscus mealybug for a moment. How might this mealybug be transmitted from one farm in the Caribbean to another in South Florida; or from one island in the Caribbean to another in the Caribbean; or from one country to another in the hemisphere?

Of course, if you know what commodities any specific bug lives on, then you would have a list of commodities that need to be monitored and treated before any are shipped anywhere. Thus it appears that one or more new on-line data banks may be needed to facilitate timely pest management and control in the Caribbean Basin.

(Note that I am assuming that most of the data we need is not readily available on the Internet at this time. Furthermore, if such a data bank, or data banks, were already on line, there would be little reason for most of us to be here in Homestead today.)

New Data Bank Proposal

Ideally, any on-line data bank of this kind, should contain some basic data that we normally would use to identify and manage any pest or potential pest that might be of concern to some of us at this workshop.

Some of the things we need to know about any potential pest or exotic species in our data bank are: current ranges (geographic distributions) of known infestations; life cycles; host plants (or animals); methods of transmission; methods of control and eradication; and country-by-country quarantine regulations.

Therefore, I am hoping this workshop, among other things, may catalyze the development of one or more new comprehensive data banks, which any of us can readily refer to on the Web.

But, in the absence of "perfect knowledge" we still can identify some shortcuts that will facilitate risk assessments and management, crop by crop, pest by pest, country by country, whenever we get around to it. And this is where some implied economics began to enter my thoughts as I prepared these remarks.

From my perspective, there are several basic questions that need to be considered for any economic assessment. For example, I would like to know:

- Where specific agricultural products are produced,
- Which countries import and export specific commodities,
- Where populations of specific pests are currently found,
- What products are known vectors of each pest,
- What avenues are open for potential transmission of specific pests, and,
- What geographic entities in the GCB should be the initial focus of our attention?

This is my conceptual starting point, and the presentation that follows is based on many years of experience trying to help others focus on their issues of primary concern, so that the data and procedures employed in their analysis will lead to useful and acceptable conclusions. But before I get to the results of

my analysis, let me give you a little more background information.

Data Sources, Definitions, and Limitations

International agricultural production and trade flows are primarily monitored and recorded by individual country governments and international organizations. Many different agencies within these national and international organizations are frequently charged with the task of collecting, tabulating, and publishing country and commodity summaries. Consequently, it is of little wonder that users frequently have problems interpreting data published by different government agencies and organizations.

Commodity definitions and presentation formats often vary dramatically from one series to the next. Furthermore, each agency frequently has a vested interest in preserving the uniqueness of the information it generates. Nevertheless, there is growing support for the continuing development of international standards and nomenclatures for all commodities traded, including agricultural commodities.

Two of the commonly used international trade classification systems are; the Harmonized System (HS; sometimes HTS, Harmonized Tariff Schedule) and the Standardized International Trade Classification (SITC) system. But many countries still use their own modifications of one or more older systems, as well as the newer ones.

Before the age of computers, countries attempted to minimize the time and cost of preparing and printing statistical summaries by aggregating commodities as much as possible before publishing. Consequently, commodities are still often aggregated according to the legal responsibilities of specific government agencies preparing them, rather than by some other national or international system. In addition, statistical reports that contain highly aggregated statistics, often have limited usefulness for monitoring production and trade flows of high-risk commodities. The HS system is better suited than any other for supporting the type of analysis I would like to make. It provides more detail than any other widely used system at present.

Massive international efforts are now being developed to standardize commodity and regional definitions among trading partners all over the world. But the job is by no means complete. For example, very little information is available on the varieties (family, genus, and species) of agricultural commodities entering international trade.

The primary sources of information used for this analysis have either been tabulated from official United States government sources, or from official publications and databases maintained by the UN Food and Agricultural Organization (FAO) in Rome. Individual country statistics are also available and very useful, but I did not have time to review 35 country sources for this workshop. Furthermore, I didn't really know which commodities to highlight when I started this paper. So the statistics that are presented below are also highly aggregated, however, they hopefully will provide a framework for planning further studies.

If more in-depth analyses are needed at the close of this workshop, then some priorities will need to be identified in the coming months, because there are several hundred commodities, pests, and diseases that could be selected for immediate analysis.

Note, however, that several agencies within the U.S. Department of Agriculture and other federal departments, collect, tabulate, and publish special sets of agricultural production and marketing information, but regional definitions to this day are not standardized. Furthermore, every country in the Caribbean Basin also has its own ministries and statistical gathering and publishing operations. It really is a miracle that there is as much uniformity as there is between seemingly identical data sets gathered by different agencies.

Official agricultural trade statistics published by the United States are often referred to as the "FATUS" series (Foreign Agricultural Trade of the United States). The FATUS series is updated monthly, and currently contains annual summaries for about 2000 agricultural import items (HS or HTS codes) and 1500 agricultural export items. Definitions for each item are found in the Harmonized Tariff Schedule (HTS) of the United States. Canada, Mexico, and other nations attempting to join NAFTA and other free-trade associations, use similar commodity codes, but the groupings are only uniform to the 6-digit level of a 19-digit schedule.

Part of the FATUS resource was recently added to the ERS-USDA web site. But the web site contains only calendar year data for 1997 and 1998. Within a few months the annual data for the period from 1989 to date will probably be added to the site. Annual summaries, however, have been published since the 1950's.

Be aware that the HS system has been used to tabulate U.S. trade flows only since 1989. From 1975 to 1988, a different coding system was used. And prior to 1975, a similar but different set of import and export codes was used to tabulate U.S. agricultural trade flows. But, the aggregate categories found in the FATUS series are essentially the same as they were 30 years ago, which makes this series particularly useful for presentations like this one. (Less than 200 aggregate categories in the FATUS series summarize all U.S. agricultural items traded.)

The Economic Research Service (ERS) and the Foreign Agricultural Service (FAS) of the USDA are responsible for defining which commodities in the 99 chapters of the Harmonized Tariff Schedule are considered to be "agricultural" and which are "non-agricultural". Note however, that the FATUS series does not include any forestry products, or fishery products, or agricultural inputs in the totals and subtotals for agricultural products. U.S. foreign agricultural trade statistics never have included forestry, fisheries, or input items. That is why FAO has published two Agricultural Summary Tables in its agricultural yearbooks for more than 50 years. (One summary table matches the historical U.S. definition of "agriculture," and the second is published for the benefit of the other countries of the world that lump fishery, forestry, and agricultural products together in their agricultural totals.)

APHIS-USDA maintains another special set of product definitions (names) and records for identifying imports as required under federal plant protection and quarantine regulations. The APHIS fruit and vegetable list alone contains more than 800 hundred categories. In the 1980s, ERS tabulated and published annual summaries for APHIS. Unfortunately, APHIS and ERS have not had the resources to publish annual summaries since 1991. Government downsizing has hampered this project.

AMS-USDA (Agricultural Marketing Service) independently collects and publishes another unique set of fruit and vegetable shipment data — for major shipping points both domestic and foreign. AMS also maintains and

publishes daily, weekly, and monthly price reports for fresh fruits and vegetables moving through wholesale terminal markets in some larger U.S. cities. So this is another source of data that can be used to identify commodity movements and potential risks.

Special studies and reports published by other public and private companies, trade associations, and research organizations represent other potential sources of information that we have used at ERS for years. Currently, I am happy to report that several of these other resources are being computerized and eventually will be available on the Internet. But many older publications and series are still out of print and may never be made available on the Internet.

Regional Definitions and Inconsistencies

Let us go back to the map of the Caribbean Basin (Frontispiece). Maps similar to this are available from the "World Fact Book" published on the CIA Web site. This publication is updated periodically and contains a wealth of country-specific information, as well as country and regional maps. It also contains a list of international organizations, with lists of members and associate members, among other interesting country statistics.

For the purposes of this paper all the countries and states shown in the frontispiece, with the exception of the United States, Mexico, and Brazil are included in the definition of the Greater Caribbean Basin (GCB) specifically developed for this paper. But statistical summaries for this region, as defined, are not tabulated or published by any national or international organization to my knowledge.

USDA, like most other national agricultural ministries, has an official list of agricultural trading partners and regions. Currently, the U.S. government considers the "Caribbean" to be composed of 23 foreign-owned or independent island states, including the Bahamas and Bermuda. Cuba is included, although little U.S.-Cuban trade has occurred since the embargo was enacted in the early 1960s. Note however, that Puerto Rico and the U.S. Virgin Islands are considered by the U.S. government to be part of the U.S. for statistical purposes, and are not considered as foreign trading partners. FAO has a more geographic than political definition of the region, but generally follows the recommendations of the U.S. and other member countries. But still the definitions of countries and regions can be confusing from time to time.

The USDA considers the "Central American" region to be composed of only seven countries (including Panama but not Mexico). FAO includes Panama in its trade summaries for Central America and the Caribbean, along with Mexico.

The USDA and FAO agree that all countries in South America are part of South America for statistical purposes. But none of the primary compilers of international trade statistics report international trade figures for the region we have defined as Greater Caribbean Basin.

GCB, for example, includes five (5) countries located on the north coast of South America, in addition to the 30-odd Caribbean and Central American countries identified as being in the region by most international organizations. Simple data tables constructed for this paper reflect the 35-country GCB definition as closely as possible.

(A statistical nightmare arose during the Reagan administration, when the Caribbean

Basin Initiative (CBI) was enacted by the U.S. Congress in 1983, and some countries in the Basin were declared eligible for benefits and some were not. The CBI legislation however, granted most countries in the region duty-free access to U.S. markets for all unprocessed agricultural products along with processed products produced in designated Caribbean and Central American countries. Cuba is the notable exception along with some of the island states considered to be overseas departments of European countries. Special restrictions were also put on imports of a few commodities such as sugar and beef. Similarly, Guyana and Suriname, but not other countries in South America were designated as eligible for benefits (duty-free access and investment assistance) under the CBI. Colombia and Venezuela were specifically excluded.

For this analysis, the GCB includes all of these countries in the region, because commodities flow between them and among them, as well as to and from the United States and elsewhere. These trade flows, whether legal or illegal, are assumed to be potential vectors or avenues for the transmission of pests and diseases in the region.

It is important to be careful how you mix and match data from different sources, particularly when you are trying to measure absolute and relative changes in quantities of products produced, treated, traded, intercepted, etc.

Analysis and Conclusions

Keep in mind that official U.S. trade statistics were primarily used in the analysis that follows. There are two reasons for this; first, it was easier to develop special summaries for the Greater Caribbean Basin as defined, and second, it facilitated comparisons of the GCB region with the CBI region, which the USDA extensively studied in the 1980s. Furthermore, based on the research my colleagues and I completed for the Caribbean Basin Initiative in the 1980s and 1990s, it appears that the U.S. would still be the preferred market for almost any agricultural commodity exported by any country in the GCB region today. In addition, it still appears that 35 to 45 percent of all the agricultural trade in the region will still be with the U.S. well into the 21st century, as it has been for more than three decades.

This pattern of trade supports some similar findings we made in the 1980s, when ERS was asked to profile U.S. imports of "non-traditional" products for CBI countries. At the time, people talked about traditional and nontraditional products, but no one had a good definition of them. My colleagues and I developed a definition which proved to be both useful and acceptable. It provided a simple methodology for monitoring production and export changes in the CBI countries over the first 10 years of the CBI, beginning January 1, 1984.

We arrived at our definition after examining the FATUS commodity groups. It appeared that most readers could accept the idea that the crops which had earned the most foreign exchange for the CBI countries over the previous hundred years could be called "Traditional" crops, or "Traditional" exports. All other crops therefore became "Non-Traditional" by definition.

With this classification we found that seven FATUS commodity groups fit the definition of "Traditional". The seven are: Bananas and plantains; Coffee, including products; Cocoa and products; Beef and veal, fresh or chilled; Sugar, cane or beet; Molasses; and Tobacco,

Table 1. Top 10 Markets for U.S. Agricultural Commodity Exports, 1998 *

Destinations		U.S. Exports ($Billion U.S.)
All Countries		51.8
1	Japan	9.1
2	Canada	7.0
3	Mexico	6.1
4	South Korea	2.2
5	Taiwan	1.8
6	Netherlands	1.6
7	Hong Kong	1.5
8	China	1.4
9	United Kingdom	1.3
10	Germany	1.2

Source: ERS-USDA Databases

* Five other countries often among the Top 10 are: Spain, Egypt, Russia, Philippines, and Italy.

Table 2. Top 10 Suppliers of U.S. Agricultural Commodity Imports, 1998*

From:		U.S. Imports ($Billion U.S.)
All Countries		37.1
1	Canada	7.8
2	Mexico	4.7
3	Italy	1.4
4	Indonesia	1.4
5	Netherlands	1.4
6	France	1.3
7	Colombia	1.3
8	Brazil	1.2
9	Australia	1.1
10	New Zealand	1.0

Source: ERS-USDA Databases

* Five other countries often among the Top 10 : Germany, Chile, Costa Rica, Thailand, and China.

unmanufactured. This proved to be very useful when we put the numbers together (see The CBI Marketing Handbook). In the years before the CBI became law, traditional products accounted for 95 percent of all Caribbean and Central American exports to the U.S. During the next 10 years, the share of nontraditional products imported by the U.S. from the CBI region slowly but steadily increased each year, even while traditional exports stagnated or declined. That trend continued for about 10 years before it leveled out. Today, the same seven Non-Traditional imports from the CBI countries, and the GCB countries, account for 20 to 25 percent of total imports from the region, depending on annual variations in volume and market prices. The full effects of the CBI appear to be over, but the seven traditional exports of the Basin continue to dominate U.S. agricultural imports from the region.

In 1997, FAO reported that the GCB (excluding Cuba) exported almost $11.3 billion of agricultural products to the world, including exports to others in the region. During the same period, FATUS summaries show the U.S. imported about $4.2 billion of agricultural products from all countries in the region. (Cuba is excluded in this comparison because the U.S. does not import anything officially from Cuba.)

In 1998, the U.S. exported more than $51.8 billion of agricultural products to the World (Table 1). Nearly $3.8 billion of this total was exported to GCB countries. Thus GCB is clearly a significant agricultural trading partner of the U.S., and has been for many years.

How does the GCB market rank in relation to the top 10 agricultural markets for the U.S. (Table 1)? The top ten markets for U.S. agricultural products in the world account for nearly 65 percent of this calendar year's export trade. Japan, Canada, and Mexico are the three largest country markets for U.S. agricultural products in the world, but none of the 35 GCB countries are among the top 10. The GCB group, however, continues to be a $3.5 -$4.0 billion market for U.S. agricultural products annually. If the U.S. had normal relations with Cuba, the GCB market for the U.S. agricultural products would likely be $4.5-$5.0 billion annually, which is significant. But this also highlights the volume of products that have to be monitored by Caribbean countries trying to keep pests and diseases out of their respective countries.

Similarly, Table 2 illustrates the potential for bringing pests (insects and diseases) into the U.S. on agricultural products. In 1998, for example, the U.S. imported more than $37 billion of agricultural products from all over the world. The top 10 suppliers accounted for nearly 60 percent of all agricultural imports form the world.

The GCB accounted for $4.9 billion dollars, or 13 percent of the total U.S agricultural imports, which is also significant. The GCB region, therefore, supplies almost as much product to the U.S. market as our second highest supplier, Canada. But Mexico clearly remains the Number One foreign supplier to the U.S. agricultural market, with shipments totaling $7.8 billion in 1998. These statistics highlight the potential for transmitting pests and diseases to the U.S. from our North American and Caribbean neighbors.

These tables also show that the world's principle agricultural trading partners of the U.S. are primarily the more developed or high income countries of the world. In other words, the agricultural trading nations of the world tend to be the ones that can afford to buy the surpluses produced by other relatively high-income countries. Poor countries simply can not afford to buy very many agricultural products in world markets, unless someone is willing to give them some aid. (FAO data provide a similar pattern of agricultural trading among the nations of the world)

Earlier it was assumed for purposes of this analysis that imports of "unprocessed agricultural products" coming out of the Caribbean, or any other country in the world, would be the most likely vectors of insects and diseases moving from country to country. So now let's focus on unprocessed products entering the United States from the GCB region.

In 1998, the U.S. imported $8.4 billion of unprocessed products from the world (Table 3). The unprocessed product categories, as reported in the U.S. FATUS series, account for only about 20 percent of all U.S. agricultural imports in recent years. Furthermore, this segment of U.S. trade is dominated by 3 principal product groups: Bananas and plantains; Fresh and frozen fruits; and Fresh or frozen vegetables. Bananas and plantain are probably low risk commodities because all commercial shipments are treated before they are shipped.

But what proportion of these 9 product groups originate in the Greater Caribbean Basin?

Unprocessed products from the GCB account for about 40 percent of all U.S. agricultural imports from the region (Table 4). Now it begins to become apparent that the Caribbean basin is a significant supplier of four categories of unprocessed products in the U.S. market: Bananas and plantain; Fresh and frozen fruits; Fresh and frozen vegetables; and Cut flowers. This also suggests that the risks of transmitting

pests and disease in shipments of the five other selected categories are relatively low, simply because the volume exported to the U.S. is relatively small. But this conclusion clearly needs further research.

But where are these products being produced in the Basin for export to the United States?

The next three tables paint a considerably clearer picture of where unprocessed products are being produced in the Basin for the U.S. market. FATUS trade summaries show that cut flowers are primarily produced in Columbia and to a lesser degree in Central America. Similarly, GCB bananas primarily come from Colombia and Central America. It is also very clear that the only unprocessed products currently being shipped from the north coast of South America to the United States are: Cut flowers, Bananas and plantains (Table 5).

The next table, for the island part of the Basin, shows that a few fresh and frozen fruits and vegetables, plus a few tropical nuts, are being shipped to the United States annually, but not much else of an unprocessed nature (Table 6). That indicates that the remainder of the unprocessed trade must be coming from Central America (Table 7).

Now trade flows of unprocessed products out of the GCB, are quite clear. Central America is a significant supplier of bananas and plantains and other fresh and frozen fruits, plus smaller but significant quantities of vegetables, cut flowers, nursery stock, nuts, and seeds for planting (Table 7).

Furthermore, the Basin does not appear to be a significant supplier of products in the crude and natural drugs category or the other unspecified products category. This is confirmed by the next table that shows the percentage of each of the unprocessed commodity group, imported by the U.S., from the entire GCB. For example, 70 percent of the bananas and plantains and 65 percent of cut flowers imported by the U.S. come from the GCB (Table 8). In addition, the GCB supplies about 15 percent of all the other fresh and frozen fruits imported by the U.S. On the other hand, the GCB is a minor supplier of all other unprocessed products summarized by these "FATUS" categories (Table 8).

Now we know which commodity groups are most likely to be vectors for the transmission of insects and diseases to the U.S. from the GCB. This is not the whole story by any means, but it provides a starting point for attempting to determine what additional research is needed to assist with the assessment of which agricultural commodities are "Critical" ones.

This leaves only one of the original objectives for this analysis unresolved: What is the potential for expansion of production of current crops and new crops in the Basin that are likely to be exported to the U.S. market over the next 10 to 20 years?

With the exception of Cuba, which remains a big question mark, the outlook is dim. Do not look for any significant expansion of agricultural production in the GCB for export to the U.S. or any other country of the world.

Even if some expansion occurs, it will likely be confined primarily to 4 or 5 countries in the Basin with the largest arable land resources in the region. Clearly, it is not going to happen in most of the small island countries. Why? First, the islands are large net importers of agricultural products. Second, they don't have the agricultural resources to produce the crops. Third, even with duty-free access to the U.S. market for most products for more than 15 years, the volume exported to the U.S. has not increased appreciably, while U.S. agricultural imports have more than doubled.

Again, some additional research on new production and trade opportunities could be undertaken, but it isn't likely to be very rewarding or cost effective.

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Table 3. Unprocessed Portion of Total Agricultural Products Imported by the U.S. from the World, 1997–98

FATUS Categories		1997	1998	1997	1998
		Million U.S. Dollars		Percent	
Total Agricultural Products		36,300	37,073	100	100
Unprocessed Items		7,440	8,445	20	23
	Sum	7,439	8,442	---	---
	Bananas, Plantain	1,220	1,201	3	3
	Drugs, Crude Natural	471	529	1	1
	Fruits, Fresh/Frozen	1,369	1,589	4	4
	Nuts and Preps	598	629	2	2
	Vegies, Fresh Frozen	2,105	2,632	6	7
	Seeds, Field/Garden	371	424	1	1
	Cut Flowers	595	614	2	2
	Nursery Stock	408	466	1	1
	Other (Not Specified)	302	358	1	1

Source: ERS-USDA FATUS Databases (http://www.econ.ag.gov/db/fatus)

Table 4. Unprocessed Portion of Total Agricultural Products Imported by the U.S. from the Greater Caribbean Basin*, 1997–98

FATUS Categories		1997	1998	1997	1998
		Million U.S. Dollars		Percent	
Total Agricultural Products		4,250	3,930	100	100
Unprocessed Items		1,630	1,600	38.4	40.7
	Sum	1,626	1,598	---	---
	Bananas, Plantain	856	812		
	Drugs, Crude Natural	3	3		
	Fruits, Fresh/Frozen	222	218		
	Nuts and Preps	20	16		
	Vegies, Fresh Frozen	103	123		
	Seeds, Field/Garden	10	9		
	Cut Flowers	386	387		
	Nursery Stock	23	27		
	Other (Not Specified)	3	3		

Source: ERS-USDA FATUS Databases (http://www.econ.ag.gov/db/fatus)

* Includes Colombia, Venezuela, Guyana, Suriname, and all the Caribbean Islands and Central American countries, including Panama, but not Mexico.

Table 5 — Unprocessed Portion of Total Agricultural Products Imported by the U.S. from South American Caribbean Countries*, 1997–98

FATUS Categories		1997	1998	1997	1998
		Million U.S. Dollars		Percent	
Total Agricultural Products		1500	1400	100	100
Unprocessed Items		560	556	37.3	39.7
	Sum	559	556		
	Bananas, Plantain	193	189		
	Drugs, Crude Natural	---	---		
	Fruits, Fresh/Frozen	---	---		
	Nuts and Preps	0	0		
	Vegies, Fresh Frozen	5	5		
	Seeds, Field/Garden	0	0		
	Cut Flowers	359	360		
	Nursery Stock	1	1		
	Other (Not Specified)	1	1		

Source: ERS-USDA FATUS Databases (http://www.econ.ag.gov/db/fatus)

* Includes only Colombia, Venezuela, Guyana, and Suriname, by definition.

Table 6 — Unprocessed Portion of Total Agricultural Products Imported by the U.S. from the Caribbean Islands, 1997–98

FATUS Categories		1997	1998	1997	1998
		Million U.S. Dollars		Percent	
Total Agricultural Products		530	460	100	100
Unprocessed Items		73	77	13.8	16.7
	Sum	73	77		
	Bananas, Plantain	5	3		
	Drugs, Crude Natural	3	3		
	Fruits, Fresh/Frozen	18	29		
	Nuts and Preps	10	10		
	Vegies, Fresh Frozen	23	29		
	Seeds, Field/Garden	---	---		
	Cut Flowers	2	1		
	Nursery Stock	1	2		
	Other (Not Specified)	1	1		

Source: ERS-USDA FATUS Databases (http://www.econ.ag.gov/db/fatus)

Table 7 — Unprocessed Portion of Total Agricultural Products Imported by the U.S. from Central America, 1997–98

FATUS Categories		1997	1998	1997	1998
		Million U.S. Dollars		Percent	
Total Agricultural Products		2220	2070	100	100
Unprocessed Items		995	965	44.8	46.6
	Sum	994	965		
	Bananas, Plantain	658	620		
	Drugs, Crude Natural	---	---		
	Fruits, Fresh/Frozen	194	190		
	Nuts and Preps	10	6		
	Vegies, Fresh Frozen	75	89		
	Seeds, Field/Garden	10	9		
	Cut Flowers	25	26		
	Nursery Stock	21	24		
	Other (Not Specified)	1	1		

Source: ERS-USDA FATUS Databases (http://www.econ.ag.gov/db/fatus)

Table 8 — Greater Caribbean Basin* Shares of Total U.S. Imports of Selected Unprocessed Commodity Items or Groups, 1997–98

FATUS Categories		1997	1998
		Percent	
Total Agricultural Products		11.7	10.6
Unprocessed Items		21.9	18.9
	Bananas, Plantain	70.2	67.6
	Drugs, Crude Natural	0.6	0.6
	Fruits, Fresh/Frozen	16.2	13.7
	Nuts and Preps	3.3	2.5
	Vegies, Fresh Frozen	4.9	4.7
	Seeds, Field/Garden	2.7	2.1
	Cut Flowers	64.9	63.0
	Nursery Stock	5.6	5.8
	Other (Not Specified)	1.0	0.8

Source: ERS-USDA FATUS Databases (http://www.econ.ag.gov/db/fatus)

* Includes Colombia, Venezuela, Guyana, Suriname, and all the Caribbean Islands and Central American countries, including Panama, but not Mexico.

Table 9 — Agricultural Trade of Greater Caribbean Basin: Value, 1997

Country	Region	Element		
		Imports	Exports	Net Exports
Greater Caribbean Basin	GCB	8,994,815	12,223,203	3,228,388
Costa Rica	C.A.	325,198	1,609,218	1,284,020
Guatemala	C.A.	543,487	1,489,677	946,190
El Salvador	C.A.	540,783	720,900	180,117
Nicaragua	C.A.	214,005	370,457	156,452
Honduras	C.A.	383,792	513,616	129,824
Belize	C.A.	55,823	114,331	58,508
Panama	C.A.	309,932	332,606	22,674
Subtotal	C.A.	2,373,020	5,150,805	2,777,785
Cuba	C.I.	692,249	934,580	242,331
Saint Vincent/Grenadines	C.I.	31,951	34,512	2,561
Saint Kitts and Nevis	C.I.	24,137	22,909	(1,228)
Montserrat	C.I.	6,430	19	(6,411)
British Virgin Islands	C.I.	9,516	16	(9,500)
Dominica	C.I.	35,120	21,797	(13,323)
Grenada	C.I.	36,392	13,257	(23,135)
Saint Lucia	C.I.	63,785	33,613	(30,172)
Antigua and Barbuda	C.I.	40,357	1,410	(38,947)
Cayman Islands	C.I.	56,812		(56,812)
Aruba	C.I.	72,950	10,994	(61,956)
Jamaica	C.I.	362,668	292,871	(69,797)
Barbados	C.I.	168,030	96,386	(71,644)
Trinidad and Tobago	C.I.	304,886	228,720	(76,166)
Bahamas	C.I.	217,224	63,374	(153,850)
Netherlands Antilles	C.I.	212,351	58,120	(154,231)
Dominican Republic	C.I.	559,838	395,564	(164,274)
Haiti	C.I.	301,063	25,790	(275,273)
Subtotal	C.I.	3,195,759	2,233,932	(961,827)
Subtotal, w/o Cuba		2,503,510	1,299,352	(1,204,158)
Colombia	S.A.	1,766,148	4,025,877	2,259,729
Guyana	S.A.	64,290	226,421	162,131
Suriname	S.A.	67,673	46,372	(21,301)
Venezuela	S.A.	1,527,925	539,796	(988,129)
Subtotal	S.A.	3,426,036	4,838,466	1,412,430

Source: FAOSTAT DATABASES

Table 10 — Agricultural Production Indices, Greater Caribbean Basin, 1998*

Country/Region	Agricultural Production Indices 1998	
	Total	Per Capita
World	115.8	103.2
NAFTA	120.6	109.2
Mexico	124.3	108.1
United States of America	118.8	110.2
Canada	118.7	109.3
Latin America (with Mexico)	122.6	107.5
South America	124.1	108.2
Central America	120.3	98.3
Caribbean	101.9	93.5
Greater Caribbean Basin	108.9	96.5
Guyana	175.5	163.2
Netherlands Antilles	148.4	140.9
Belize	160.7	130.9
Bahamas	147.3	128.2
Saint Kitts and Nevis	114.1	116.9
Jamaica	118.3	110.3
Montserrat	110.2	110.2
Martinique	117.1	107.4
Grenada	107.7	105.4
Costa Rica	122.2	101.6
Guadeloupe	112.2	98.7
U.S. Virgin Islands	103.4	98.6
Venezuela	114.8	96.3
Honduras	120.2	95.4
Nicaragua	118.6	94.9
Antigua and Barbuda	98.6	94.2
El Salvador	112.9	93.8
Guatemala	115.7	92.1
Barbados	93.6	91.5
Dominican Republic	105.5	91.1
Trinidad and Tobago	97.1	91.1
Dominica	90.6	90.6
Colombia	104.3	90.4
French Guiana	127.1	90.1
British Virgin Islands	104.1	84.9
Haiti	93.2	80.1
Panama	92.1	79.8
Suriname	87.1	78.8
Saint Vincent/Grenadines	84.6	78.8
Puerto Rico	81.8	75.8
Cayman Islands	84.9	64.4
Saint Lucia	68.6	61.7
Cuba	62.1	59.3
Total	3594.6	3187.4

Source: FAOSTAT Databases.

1. Calendar year 1989-91 average equals 100.

Table 11 — Total and Arable Land in Greater Caribbean Basin, 1997

Countries and Regions	Land Use	
	Total Area (1000Ha)	Arable Land (1000Ha)
NAFTA	2,128,942	247,710
United States	936,061	176,950
Canada	997,061	45,560
Mexico	195,820	25,200
Latin America	2,058,182	139,388
Caribbean	23,470	5,659
Central America (includes Mexico)	247,980	32,066
South America	1,786,732	96,004
Greater Caribbean Basin (w/o Mexico)	327,550	17,641
Antigua and Barbuda	44	8
Aruba	19	2
Bahamas	1,388	6
Barbados	43	16
Belize	2,296	64
British Virgin Islands	15	3
Cayman Islands	26	
Colombia	113,891	1,929
Costa Rica	5,110	225
Cuba	11,086	3,700
Dominica	75	3
Dominican Republic	4,873	1,020
El Salvador	2,104	565
French Guiana	9,000	10
Grenada	34	2
Guadeloupe	171	18
Guatemala	10,889	1,360
Guyana	21,497	480
Haiti	2,775	560
Honduras	11,209	1,695
Jamaica	1,099	174
Martinique	110	10
Montserrat	10	2
Netherlands Antilles	80	8
Nicaragua	13,000	2,457
Panama	7,552	500
Puerto Rico	895	33
Saint Kitts and Nevis	36	6
Saint Lucia	62	3
Saint Vincent/Grenadines	39	4
Suriname	16,327	57
Trinidad and Tobago	513	75
Turks and Caicos Is	43	1
U.S. Virgin Islands	34	5
Venezuela	91,205	2,640

Source: FAOSTAT Databases

Offshore Pests and Pathogens That Threaten Fruit and Vegetable Production in the Caribbean Region

Daniel A. Fieselmann
USDA-APHIS-PPQ-CPHST, Raleigh Plant Protection Center
Raleigh, North Carolina

Abstract

Caribbean Basin nations are vulnerable to pest invasion. Many significant pests have already invaded and spread throughout the Basin causing significant economic and environmental damage. Quarantines to exclude pests from Basin countries have been in effect for many years. Increases in trade and tourism have overwhelmed plant protection services prevention efforts. Comprehensive records of Caribbean pest introductions and distributions are not readily accessible, hindering quarantine effectiveness. Pest invasions will continue at a high rate unless coordinated Basin wide strategies are developed and implemented. More effective quarantines will result from coordinated exclusion programs, standardized pest detection and regulatory practices, improved information management and exchange, and proactive pest management programs.

Discussion

The Caribbean Basin, defined broadly to include the adjacent Latin American countries and the U.S. Gulf Coast states, comprises an ecologically rich and varied region. With mountains as well as lowlands, and areas of wide divergence in rainfall, the Caribbean Basin provides suitable habitat for a wide variety of exotic pest invaders. An alarmingly large number of economically significant insects, mites, mollusks, pathogens, weeds and other pests have made their appearance in recent years (Brown 1980, Caribbean/Latin American Profile 1999, Schmutterer 1990).

Early concern about the movement of pests led to the enactment of plant quarantine laws in the latter part of the nineteenth century. Examples of such laws include: Jamaica 1884 and 1891; Trinidad and Tobago 1890 and 1894; Grenada 1891; St. Vincent, St. Lucia 1895; Antigua, Montserrat, British Virgin Islands 1897; and Dominica 1898 (Pollard 1986).

Pests and pathogens move to new areas by a variety of pathways, both natural and commercial. Natural spread may be aided by wind and water currents and storm events such as hurricanes. Human actions create many potential pathways for pest introduction and colonization. Examples include: international mail, air cargo, air passenger baggage, sea freight, ship and aircraft stores, vehicles and railroad cars at land border

crossings, yachts and private aircraft, cruise ships, and military transport. In the U.S., the Animal and Plant Health Inspection Service (APHIS) has determined that smuggling constitutes a major pathway for the entry of uninspected and often infested quarantine materials.

APHIS's Agricultural Quarantine Inspection Monitoring program develops revealing statistical data about the effectiveness of quarantine inspections. The monitoring program sampling protocols enable the agency to quantify the pest pressure at the border. For particular pathways at a port of entry, monitoring statistics determine the approach rate for quarantine materials. Records for actual quarantine materials intercepted are known. By comparing the approach rate with the actual rate of interception, one can determine the percent of quarantine materials missed by inspection. Monitoring has determined that this "gap" is rather significant, underscoring the need to strengthen exclusion programs.

Monitoring inspections conducted in Miami in the spring of 1999, demonstrate that importation pathways bring significant levels of quarantine materials to the border. As shown below, refrigerated sea freight containers and other modes of entry present a substantial quarantine risk. The actual interception rates recorded from daily operations are significantly less, meaning that a large quantity of quarantine materials and pest organisms are moving beyond the port of entry. This is the gap that needs to be closed by more rigorous inspections, more stringent regulations, or altered trading patterns.

Table 1. Percentage of Shipments Requiring Quarantine Action Listed by Pathway

Pathway		Quarantine Action Required
Maritime cargo	Refrigerated containers	14.0%
	Non-refrigerated containers	11.9%
Air cargo shipments		9.7%,
Cruise ships passenger baggage		7.3%
Air passenger baggage		4.0%

Pollard (1986) lists the following record of pest introductions into the Caribbean Basin with the year and location: diamond-back moth (1945) Trinidad; leaf-cutting ant (1954) Guadeloupe; coconut mite (1960) Mexico; lethal yellowing (1961) Jamaica; small moth borer (1965) Bahamas; sugarcane smut (1974) Guyana; Cedros wilt (1976); sugarcane rust (1978) Dominican Republic; Moko disease (1978) Grenada; coffee berry borer (1978) Jamaica; Africanized bee (1979) Trinidad; sugarcane thrips (1980) Barbados and Guadeloupe; mango seed weevil (1984) St. Lucia; coffee leaf rust (1985) Belize and Cuba.

Since the 1986 publication above, Caribbean Basin nations have witnessed the increased spread of invasive pest species. A few of the more notable outbreaks include citrus canker, pink hibiscus mealybug, small hive beetle, papaya mealybug, TYLC Virus, citrus leafminer, black parlatoria scale, brown citrus aphid, *Thrips palmi*, black Sigatoka disease of bananas, rice stalk stinkbug, and tropical soda apple. These listed pests are spreading among Basin countries. Other potential introductions include khapra beetle, citrus greening disease, several diseases of cassava, the giant salvinia aquatic weed, and the giant African snail. It

should be noted that several infestations of Mediterranean fruit fly and oriental fruit fly have been eradicated from Florida in recent years. These two fruit flies pose a major threat to Basin agriculture.

The lack of current, comprehensive pest records for the Caribbean Basin create a challenge. Plant protection organizations need this information to strategically plan pest exclusion and detection programs. Significant improvements in record and data management for the region are not expected in the near term. For now, quarantine effectiveness can be improved through the use of pest lists that flag the highest priority threats and the probable pathways for entry. APHIS has contracted with several scientific societies to prepare these type lists to aide plant protection programs in the U.S.

Given the lack of consolidated pest information for the Basin, the following Web sites provide examples of the useful international pest information found on the Internet (Table 2).

In conclusion, the Caribbean Basin is quite vulnerable to pest invasion. The numerous documented introductions over the past century are increasing, resulting in serious economic and environmental damage. The various national plant protection services cannot cope individually with the increases in trade and tourism. Since pests once introduced to the Basin spread so readily between countries, a more regional approach is suggested. Coordinated, Basin-wide strategies might include increased emphasis on rigorous phytosanitary export inspection, improved taxonomic support and training, and proactive biocontrol and pest management programs, like the pink hibiscus mealybug program, to reduce the impact of new pest distributions. Public awareness campaigns to highlight the invasive species problem are essential. Coordinated regional pest detection surveys and improved record keeping and data management would improve the prospects for preventing new pest problems. This Basin wide strategy provides a better alternative to the current expensive, often ineffective, reaction to pest outbreaks by individual countries. The result should yield fewer pest outbreaks with less agricultural and environmental damage.

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Table 2. Web sites with Useful Pest Information

Univ. of Florida Pest Alert		http://extlab1.entnem.ufl.edu/PestAlert/
Florida Entomologist		http://www.fcla.edu/FlaEnt/
Calif. Dept. Food & Agr.		http://www.cdfa.ca.gov/pests/updates/
ProMed		http://www.healthnet.org/programs/promed.html
Institut Nat'l Recherche		http://www.inra.fr/HYPPZ/pests.htm
European Plant Prot. Org.		http://www.eppo.org/index.html
Mexico		http://ns1.oirsa.org.sv/Castellano/Sitios/Direcciones.htm
Australia		http://www.agric.wa.gov.au/ http://www.aqis.gov.au/
Mollusks		http://erato.acnatsci.org/ams/
Weeds		http://refuges.fws.gov/NWRSFiles/InternetResources/Weeds.html http://plants.ifas.ufl.edu/
IPM	Woody Pests	http://www.ifas.ufl.edu/~pest/woodypest/
	Whiteflies	http://www.ifas.ufl.edu/~ent2/wfly/ http://ipmwww.ncsu.edu/cipm/ http://ipmworld.umn.edu/
Plant Pathology	APS	http://www.scisoc.org/
	Viruses	http://biology.anu.edu.au/Groups/MES/vide/
	Nematodes	http://www2.oardc.ohio-state.edu/nematodes/ http://www.ars-grin.gov:80/ars/Beltsville/barc/psi/nem/home-pg.html
	Texas	http://cygnus.tamu.edu/Texlab/tpdh.html
	Mycology	http://@nt.ars-grin.gov/fungaldatabases/databaseframe.cfm
FAO	Home page	http://www.fao.org/
	Plant Pest Info Syst.	http://pppis.fao.org/
	IPPC	http://www.fao.org/ag/AGP/AGPP/PQ/
APHIS	Hot Issues Section	http://www.aphis.usda.gov/
	Press Releases	http://www.aphis.usda.gov/lpa/press/press.html
	NAPIS Database	http://ceris.purdue.edu/napis/
USDA	Nat'l Ag. Lib.	http://www.nal.usda.gov/
	ARS	http://www.ars.usda.gov/
	Forest Service	http://www.fs.fed.us/

History of Introduced Pests in Puerto Rico and Potential Introductions

Rosa Franqui
Agricultural Experiment Station, University of Puerto Rico
Rio Piedras, Puerto Rico

Introduction

The following four groups of tables summarize information for pest introductions into Puerto Rico from 1963 to 1999:

Group 1 — Insect Pest Introductions for selected years from 1963 to 1999.

Group 2 — Most Serious Pest Introductions from 1970 to 1999; Each table gives selected introduced species for a particular insect family.

Group 3 — Intercepted Pests by Country from 1985 to 1996; Generally, each table gives the interceptions of a particular family.

Group 4 — This table lists Insect Species Interceptions for the period 1997 to 1999.

Interceptions as reported were made at International Airport Luis Muñoz Marín located near San Juan, Puerto Rico.

In addition to the pests reported in the tables, the following have appeared in the Caribbean Basin and seem destined to arrive in Puerto Rico:

- Hyphotenemus hampeii
- Cryptorhynchus mangiferae
- Rhyncophorus palmarum
- Rhinostomus barbirostris
- Anastrepha ludens
- Ceratitis capitata
- Myndus crudus

Introduced Pests 1970-1999

Table 1. Insect Pest Introductions 1963-1999

Year	Number of Species
1963	2
1965	2
1971	4
1972	4
1973	1
1974	4
1975	2
1980	1
1981	1
1982	2
1983	1
1984	1
1986	2
1987	5
1988	4
1990	3
1994	2
1995	3
1996	4
1997	2
1998	4
1999	1

Table 2. Most Serious Introduced Pests: Homoptera 1970-1999 (for selected species)

Family	Number of Species per Family
Aleyrodidae	17
Aphididae	14
Asterolecaeniidae	5
Coccidae	9
Diaspididae	30
Pseudococcidae	13

Table 3. Most Serious Introduced Pests: Coleoptera 1970-1999 (for selected species)

Family	Number of Species per Family
Curculionidae	10
Bostrichidae	1
Bruchidae	6
Nitidulidae	2
Scolytidae	1

Table 4. Most Serious Introduced Pests: Diptera 1970-1999 (for selected species)

Family	Number of Species per Family
Agromyzidae	2
Cecidomyiidae	1
Tephritidae	3

Table 5. Most Serious Introduced Pests: Lepidoptera 1970-1999 (for selected species)

Family	Number of Species per Family
Gelechiidae	1
Gracillardiidae	1
Noctuidae	6
Phycitidae	1

Table 6. Most Important Insect Pests Introduced during 1970-1999 (for selected species)

Family	Number of Interceptions per Family
Entomobryidae	1
Platypodidae	1
Membracidae	1
Margarodidae	1
Formicidae	3
Kalothermithidae	1
Rhinothermithidae	3
Thripidae	3

Table 7. Most Serious Introduced Pests: Acarina 1970-1999 (for selected species)

Family	Number of Species per Family
Ixodidae	1
Tarsonemidae	1
Tetranychidae	2
Varoidae	1

Intercepted Pests 1985-1996

Table 8. Insect Species Interceptions during 1985-1996 (Interceptions at the International Airport Luis Muñoz Marín 1985-1996)

Country	Number of Interceptions
Antigua & Barbados	25
Colombia	72
Costa Rica	56
Dominica	36
Dominican Republic	120
Grenada	32

Table 9. Most Common Insect Species Intercepted 1985-1996: Homoptera: Pseudococcidae (Interceptions at the International Airport Luis Muñoz Marín 1985-1996)

Country/Island	Number of Interceptions
Antigua	1
Aruba	3
Barbados	1
Dominican Republic	9
Grenada	4
Guadeloupe	1
Guatemala	1
Martinique	2
St. Christopher	2
St, Lucia	1
Trinidad & Tobago	2
Venezuela	1

Table 10. Most Common Insect Species Intercepted 1985-1996: Homoptera: Dispididae (Interceptions at the International Airport Luis Muñoz Marín 1985-1996)

Country/Island	Number of Interceptions
CARIBBEAN	
Antigua	11
Aruba	4
Cuba	2
Dominica	1
Dominican Rep.	50
Grenada	3
Guadeloupe	3
Haiti	14
Jamaica	4
Martinique	1
St. Christopher	3
St. Croix	3
St. Lucia	6
St. Martin	7
St. Thomas	3
Tortola	1
Trinidad & Tobago	10
Virgin Islands	3
SOUTH AMERICA	
Argentina	5
Brazil	3
Colombia	18
Ecuador	2
Peru	5
Venezuela	7
EUROPE AND MIDDLE EAST	
France	1
Greece	3
Israel	1
Italy	1
Spain	1
AFRICA	
Ivory Coast	1

Table 11. Most Common Insect Species Intercepted 1985-1996: Homoptera: Cococcidae (Interceptions at the International Airport Luis Muñoz Marín 1985-1996)

Country/Island	Number of Interceptions
CARIBBEAN	
Anguila	1
Antigua	4
Aruba	4
Barbados	25
Dominica	4
Dominican Republic	36
Grenada	7
Guadaloupe	4
Haiti	3
Jamaica	1
Martinique	14
St. Lucia	2
St. Thomas	2
Trinidad & Tobago	17
Virgin Islands	8
SOUTH AMERICA	
Belize	1
Brazil	1
Ecuador	1
Mexico	1
Venezuela	1

Table 12. Most Common Insect Species Intercepted 1985-1996: Homoptera: Aphididae (Interceptions at the International Airport Luis Muñoz Marín 1985-1996)

Country/Island	Number of Interceptions
Colombia	14
Dominica	1
Dominican Republic	9
Europe	1
Martinique	1
Netherlands	1
Spain	1
St. Lucia	1
Trinidad & Tobago	1
Venezuela	3
Virgin Islands	1

Table 13. Most Common Insect Species Intercepted 1985-1996: Homoptera: Aleyrodidae (Interceptions at the International Airport Luis Muñoz Marín 1985-1996)

Country/Island	Number of Interceptions
Barbados	3
Dominican Republic	4
Israel	3
Senegal	1
St. Lucia	1
Trinidad & Tobago	1
West Germany	1

Table 14. Most Common Insect Species Intercepted 1985-1996: Thysanoptera: Thripidae (Interceptions at the International Airport Luis Muñoz Marín 1985-1996)

Country/Island	Number of Interceptions
Antigua	1
Argentina	14
Aruba	1
Colombia	3
Costa Rica	1
Dominican Republic	38
Mexico	1
Netherlands	2
Spain	1
St. Lucia	1
Trinidad & Tobago	2
Venezuela	1

Table 15. Most Common Insect Species Intercepted 1985-1996: Coleoptera:Curculionidae (Interceptions at the International Airport Luis Muñoz Marín 1985-1996)

Country/Island	Number of Interceptions
CARIBBEAN	
Antigua	7
Aruba	4
Barbados	3
Dominica	2
Dominican Republic	28
Guadaloupe	2
Martinique	2
St. Christopher	3
St. Lucia	7
St. Martin	2
Trinidad & Tobago	9
CENTRAL AND SOUTH AMERICA	
Brazil	1
Colombia	6
Costa Rica	8
Guyana	1
Honduras	1
Peru	1
Venezuela	6
EUROPE AND ASIA	
Italy	1
Pakistan	1
Spain	2
AFRICA	
Kenya	1
South Africa	2

Table 16. Most Common Insect Species Intercepted 1985-1996: Coleoptera: Crisomelidae (Interceptions at the International Airport Luis Muñoz Marín 1985-1996)

Country/Island	Number of Interceptions
Colombia	2
Dominican Republic	3
Spain	1
Venezuela	2

Table 17. Most Common Insect Species Intercepted 1985-1996: Diptera: Agromyzidae (Interceptions at the International Airport Luis Muñoz Marín 1985-1996)

Country/Island	Number of Interceptions
Antigua & Barbados	1
Colombia	25
Costa Rica	3
Dominican Republic	23
Ecuador	19
Grenada	5
Martinique	1
Mexico	1
St. Lucia	1
Trinidad & Tobago	4
Venezuela	3

Table 18. Most Common Insect Species Intercepted 1985-1996: Diptera: Cecidomiidae (Interceptions at the International Airport Luis Muñoz Marín 1985-1996)

Country/Island	Number of Interceptions
Dominican Republic	4
Grenada	1

Table 19. Most Common Insect Species Intercepted 1985-1996: Diptera: Tephritidae (Interceptions at the International Airport Luis Muñoz Marín 1985-1996)

Country/Island	Number of Interceptions
CARIBBEAN	
Antigua	2
Aruba	3
Barbados	5
Dominica	2
Dominican Republic	18
Guadaloupe	1
Haiti	1
Jamaica	3
St. Christopher	1
St. Croix	1
St. Lucia	5
St. Martin	2
St. Thomas	1
Trinidad & Tobago	13
Virgin Islands	1
CENTRAL AND SOUTH AMERICA	
Argentina	1
Bolivia	1
Brazil	1
Colombia	9
Costa Rica	7
Ecuador	4
El Salvador	1
Guyana	1
Mexico	2
Panama	2
Peru	9
Venezuela	13
EUROPE AND ASIA	
Germany	2
Italy	1
Spain	10
Turkey	1

Table 20. Most Common Insect Species Intercepted 1985-1996: Lepidoptera: Geometridae (Interceptions at the International Airport Luis Muñoz Marín 1985-1996)

Country/Islands	Number of Interceptions
Canada	1
Colombia	9
Costa Rica	2
Dominican Republic	8
Israel	3
Netherlands	3
Venezuela	1

Table 21. Most Common Insect Species Intercepted 1985-1996: Lepidoptera: Gelechiidae (Interceptions at the International Airport Luis Muñoz Marín 1985-1996)

Country/Islands	Number of Interceptions
CARIBBEAN	
Antigua	1
Aruba	2
Barbados	2
Dominican Republic	11
Guadaloupe	2
Haiti	1
St. John	1
St. Lucia	2
St. Martin	2
Trinidad & Tobago	7
CENTRAL AND SOUTH AMERICA	
Colombia	1
Ecuador	1
Mexico	1
Peru	1
Venezuela	2
EUROPE	
Spain	2

Table 22. Most Common Insect Species Intercepted 1985-1996: Lepidoptera: Pyralidae (Interceptions at the International Airport Luis Muñoz Marín 1985-1996)

Country/Island	Number of Interceptions
CARIBBEAN	
Antigua	1
Aruba	1
Barbados	2
Dominican Republic	15
Grenada	1
St. Christopher	2
St. Croix	1
Trinidad & Tobago	6
CENTRAL AND SOUTH AMERICA	
Argentina	1
Colombia	4
Costa Rica	1
Nicargua	1
Panama	1
Peru	1
Venezuela	1
EUROPE AND ASIA	
Israel	1
Italy	1
Japan	1
Netherlands	1
Spain	2

Table 23. Most Common Insect Species Intercepted 1985-1996: Lepidoptera: Noctuidae (Interceptions at the International Airport Luis Muñoz Marín 1985-1996)

Country/Islands	Number of Interceptions
CARIBBEAN	
Dominican Republic	2
Haiti	6
Jamaica	1
St. Lucia	1
CENTRAL AND SOUTH AMERICA	
Brazil	34
Colombia	46
Costa Rica	1
Ecuador	9
Mexico	6
Peru	3
Venezuela	2
EUROPE	
Czechoslovakia	7
Netherlands	1
Spain	1

Intercepted Pests 1997-1999

Table 24. Insect Species Interceptions during 1997-1999 (Interceptions at the International Airport Luis Muñoz Marín 1997-1999)

Country/Island	Number of Interceptions
CARIBBEAN	
Antigua	48
Aruba	26
Barbados	68
Dominican Republic	516
Martinique	34
St. Lucia	73
Trinidad & Tobago	131
CENTRAL AND SOUTH AMERICA	
Argentina	36
Brazil	95
Colombia	318
Costa Rica	99
Ecuador	35
Venezuela	114
EUROPE	
Italy	89
Spain	149

Management of Invasive Pest Plants in Bermuda

Paradise under Siege: The Susceptibility of Oceanic Islands to Plant Invasion

Keanya Francis
Ministry of the Environment, Bermuda Zoological Society
Flatts, Bermuda

Abstract

Bermuda like many other oceanic islands has become increasingly susceptible to invasion by pest plant species. Thirty-five out of one hundred twenty species from the Florida Exotic Pest Plant Council's (FLEPPC) most invasive pest plant list are found in Bermuda; some of the more obvious pest species are *Casuarina equisetifolia*, *Ficus microcarpa*, and *Shinus terebinthifolius*. Typically, there are several factors that influence an island's susceptibility to plant invasion. However, human actions are largely responsible for the spread of non-native species and the problems associated with plant introductions. In 1997, the Ministry of Works and Engineering, the Department of Agriculture and Fisheries, and the Parks Division launched the Ficus Management Project. The aim of this project was to prevent the ecological damage caused by the Indian Laurel (*F. microcarpa*) and to communicate the extent of the problems associated with this tree. Also in 1997, the Bermuda Biodiversity Project emerged as a proactive measure to address the growing problems associated with habitat loss. The main focus of this project is to develop a comprehensive information management system for the sustainable management of the island's natural resources. Recently, "Growing with Trees" was launched as a millennium tree planting initiative, to encourage members of the public to collect and propagate native and endemic seeds. Each one of these projects integrates education as a key component. Ultimately, environmental education is necessary to address the problems associated with non-native pest plant introductions.

Discussion

Bermuda has become increasingly susceptible to invasion by non-native plants. Like many other oceanic islands, Bermuda may be on the verge of an ecological catastrophe. There have been approximately 2900 plant introductions in the brief 350 years that Bermuda has been inhabited (Thomas 1998), and in all fairness, only a small percent of the introduced plants biologically pollute the island's environment. A recent review of the FLEPPC most invasive pest plant list revealed, that approximately 32 out of 120 Category I and Category II species are present in Bermuda (FLEPPC 1999). According to FLEPPC, Category I species demonstrate an ability to invade and significantly alter a natural area, while Category II species, once introduced, can alter a natural habitat. Some of the main pest plants in Bermuda are the Fiddlewood (*Citharexylum spinosum*), Allspice (*Pimenta*

diocia), Brazilian Pepper (*Shinus terebinthifolius*), Asparagus Fern (*Asparagus sprengeri*), Surinam Cherry (*Eugenia uniflora*), Indian Laurel (*Ficus microcarpa*), Guava (*Psidium guajava*), Chinese Fan Palm (*Livistona chinensis*), and Casuarina - Australian Pine (*Casuarina equisetifolia*).

The environmental and economic damage that a few exotic species can manifest in a biotic system warrants the sounding of an alarm. Some experts consider non-native species as the second most important threat to biodiversity next to habitat destruction (Westbrook 1998). Robert E. Eplee of the U.S. Department of Agriculture was quoted as saying, "When chemical pollution or the exploitation of the environment ceases, an ecosystem begins the recovery process. Yet, when invasive organisms (biological pollutants) are introduced into a new ecosystem, they can grow, adapt, proliferate and spread... indefinitely," (Westbrook 1998). From an economic prospective, the impact of pest plants on the U.S. economy is estimated at $20 billion or more annually (Westbrook 1998). On an oceanic island, serious economic considerations also become apparent especially when the economy is based largely on tourism. Unattractive tourist areas that are devoid of wildlife or species diversity may have a negative effect on the economy.

Typically, there are several factors that contribute to the susceptibility of an island's ecology to plant invasion. Generally, oceanic islands exhibit species poverty. This is usually attributed to their remoteness from continental sources of flora and fauna (Cronk and Fuller 1995). Often, species poverty precludes vigorous competition from native species. Subsequently, invasive plant introductions are more likely to out-compete native flora because native plants have evolved in isolation: "Invasives are often more vigorous because they are introduced from their homeland without their complement of insects, pests, and diseases that co-evolved with them" (Wingate, personal communication). An example of the potential problem associated with species evolution in isolation can be seen in Hawaii where non-native grasses have altered the natural fire cycle. The introduced grasses primarily fuel fires, which are generally destructive to native plants (Westbrook 1998). Sooner or later the native species are virtually eliminated by fire, and the invasive grasses become pioneers in the disturbed area. The small scale of an oceanic island is another factor that facilitates an island's susceptibility to invasion. Most oceanic islands lack the physical features that limit human exploitation, disturbance and species introduction (Cronk and Fuller 1995). Also, the relatively concentrated dispersal distance within an island can simulate an exaggerated ecological release of introductions.

Pest plants notwithstanding, it is the human influence that has had the greatest impact on an island's biota. Anthropogenic impacts have been so intense throughout much of the Caribbean that (exotic) non-native species have successfully become established in this region (Lugo 1988). It has been documented that the Brazilian Pepper (*S. terebinthifolius*), and the Casuarina -Australian Pine (*C. equisetifolia*) are some of the most pernicious plants to have invaded Bahamas via the hand of man (Campbell 1978).

Generally, population growth and population density leads to greater disturbances of the land, which encourages the establishment of invasive plants (Westbrook 1998). Over the past years, the Bermuda's population growth has sparked continual development and the alteration of an already fragile system. Between 1970 and 1990, the resident population increased 16%; employment grew 34%; 7,800 dwelling units were constructed representing a 44% increase in the housing stock; the number of private cars increased by 74%; and tourist arrivals per annum went up 178,000 or 46%. Of course, Bermuda remained just over 19 square miles in area (Bermuda Planning Statement 1992).

There are three major vegetation zones in Bermuda: coastal, peat marsh, and upland zones. Unfortunately, human activity has completely altered the upland zone. Most of the housing developments, quarry excavations, woodland clearing, agriculture, and non-native plant introductions have occurred in this zone. Moreover, virtually all of the native and endemic species have become extinct in this area (D. Wingate 1971). Currently, measures taken to enhance the quality of the various zones are: extensive woodland protection; qualitative assessments; replanting schemes; and required landscape proposals (Bermuda Planning Statement 1992). Unfortunately, most conservation laws are difficult to enforce, and conservation laws alone do not solve the dilemma linked with invasive plants. General environmental problems have been compounded by specific characteristics of the island's sociology, geography, economy, and demography (D. Wingate 1981). Besides, many island residents have strong reasons for importing or protecting non-native species as agricultural, cultural, or ornamental necessities (Vitousek 1988). A lack of concern or awareness for the island environment only adds to the establishment of non-native pest plants. For instance, many plant invaders have become so well integrated into the natural landscape that most locals consider these plants native (A. Lugo 1988). Ironically, there are a numerous places in Bermuda where Brazilian Pepper (*S. terebinthifolius*), Asparagus Fern (*A. sprengeri*), Surinam Cherry (*E. uniflora*), Indian Laurel (*F. microcarpa*), Chinese Fan Palm (*L. chinensis*), and Casuarina -Australian Pine (*C. equisetifolia*) are allowed to grow as a perimeter hedge or as a dominant urban-landscape plant.

In Bermuda, the Conservation Unit has adopted a policy of culling invasives from Nature Reserves where native flora was still dominant (Wingate, personal communication). But efforts to address the problems associated with invasive plants in upland zones have been minimal. Nevertheless, in 1997, the Ministry of Works and Engineering, the Department of Agriculture and Fisheries, and the Department of Parks launched the Ficus Management Project (FMP). The aim of this project was to prevent the ecological damage caused by the Indian Laurel (*F. microcarpa*), and to communicate the extent of the problems associated with this tree. The Indian Laurel has a tenacious root system that can undermine brick and concrete foundations. Furthermore, this plant can also invade and significantly alter natural habitats. The FMP evolved around a baseline survey, treatment programs, and a public awareness campaign. The first and most important phase of the FMP was the baseline survey, because previous estimates of *F. microcarpa* focused only on population numbers. The updated survey revealed population numbers, age, location, and characteristics such as fruit production. The proliferation of *F. microcarpa* precipitated the need for an integrated management approach. Mature trees that had the potential to produce fruit and, thus, viable seed were identified as target trees. Subsequently, the target trees were managed by either mechanical or chemical treatments. Natural or physical limiting factors controlled *F. microcarpa* seedling populations, regardless of their high numbers island-wide. Interestingly, the success of the FMP was greatly attributed to the local media coverage. After several public broadcast announcements, numerous calls were received at the FMP hotline. As a result, FMP brochures that highlighted species identification and species control measures were made available at most local plant nurseries and at the Department of Agriculture and Fisheries. The FMP Web site was also created in the summer of 1998, and to this date, it has received close to three thousand visitors.

Also in 1997, the Bermuda Biodiversity Project (BBP) emerged as a proactive measure to address the growing problems associated with habitat loss. This program was initiated by the

Bermuda Zoological Society and the Bermuda Aquarium Museum and Zoo with the aim of developing a comprehensive information management system that will facilitate the sustainable management of Bermuda's natural resources (Ward; Glasspool and Sterrer 1998). A fundamental component is the mapping of Bermuda's marine and terrestrial habitats to provide a baseline of environmental data. The BBP protocols and training programs have been designed to involve the local community and schools in specific field studies and mapping initiatives. The BBP database is being integrated with the Bermuda Government Geographic Information System (GIS) to provide government and non-government agencies with information that will relay environmental change.

Recently, the Ministry of the Environment in conjunction with the Ministry of Works and Engineering, the Bermuda Zoological Society, the Bermuda Aquarium Museum and Zoo, corporate sponsors, and non-governmental agencies launched "Growing with Trees", a millennium tree planting initiative. This project is a proactive measure to selectively improve woodland and upland zone areas through a continuing program of tree replacement. Participants are invited to collect and propagate native and endemic seed varieties, which they will plant in the new millennium. Community planting programs are used as a vehicle to inspire appreciation and care for our island environment. The Millennium Tree-Planting Guide has been produced to assist people in identifying non-native pest plants. The planting guide also contains tips and color illustrations for tree selection of native, endemic trees and site preparation. Currently, special efforts are being made to integrate the millennium tree planting initiative into the school curriculum as an extra activity.

Biological invasions appear to be an immense and largely unmanageable problem, because at present there are neither the resources nor the will to attack the problem (Vitousek 1988). As mentioned earlier, economic, social, demographic, and geographic characteristics (D. Wingate 1981), encourage the importation of alien species. Therefore, a massive support network for the control of introduced pest plant species is highly unlikely. However, if environmental resource managers, planners, non-governmental, and governmental agencies engage in proactive measures positive changes will precipitate. Environmental education should be a main focus, because it is important in influencing a positive attitude toward the environment at an early stage (Jickells, 1981). Environmental education is a key component that can be found in the FMP, BBP and Growing with Trees. Within each one of the earlier named projects numerous presentations and promotional campaigns were undertaken. Senior high school students, college students, and members of the community are often invited to participate in these programs and the contributions that are made are usually mutually beneficial. Recently, students that participated in the BBP summer session developed various research projects and presentations. Later, the students evaluated their summer experience and the communicated the depth of their learning experience. Interestingly, the students that worked in the terrestrial surveys listed the effects of invasive species as their greatest concern.

General awareness of the non-native pest plant is essential in order to limit the number of accidental introductions. Awareness involves understanding the following: a) the difference between native and alien (exotic) flora; b) the importance of native plants over and above alien plants; c) that alien species can, in some instances, threaten native ones; d) that apparently harmless activities, such as gardening or forestry, can result in the naturalization of plants (Cronk and Fuller 1995). Ultimately, environmental education can serve to raise awareness about conservation and the problem of invasive plants eroding biodiversity.

Acknowledgements

I would like to thank E. Francis, R. Brown, A. Young, Z. Francis, M. White; the Ministry of the Environment — B. Rawlins, J. Ward, C. Douglas, A. Lugo, D. Saunders; the Ministry of Works and Engineering — S. Oliver; the Department of Parks — C. Foggo, C. Burt, B. Cook, D. Wingate; Bermuda Zoological Society — R. Winchell, A. F. Glasspool, J. Furbert, H. DeSilva, P. Hill. This is contribution #028, Bermuda Biodiversity Project (BBP), Bermuda Aquarium, Natural History Museum and Zoo. The material presented here was complied as a manuscript to the proceedings at the 1999 TSTAR workshop "Mitigating the Effects of Exotic Pest on Trade and Agriculture in the Caribbean Region. "

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Exotic Weeds that Threaten the Carribean: A Brief Overview and Early Alarm

Richard Moyroud
Mesozoic Landscapes, Inc.
Delray Beach, Florida

Exotic pest plants are now a widely recognized problem throughout the United States, resulting in the publication of lists, control methods, and proposals for the identification and prevention of introduction of new pest plant species. Exotic pest plants also occur in many of the islands and mainland coasts of the Caribbean region, but have rarely been acknowledged. The behavior of exotic pest plants can best be predicted from earlier invasions elsewhere, making the Florida Exotic Pest Plant Council's published list a valuable tool in evaluating species spreading throughout the Caribbean. Many species which are now listed as "Category 1" pest plants in Florida are poised to become a serious problem for many of the natural or cultivated lands in the Caribbean Basin. Once the infestation is widespread, the cost for control of these plants is very high; it is wisest to prevent the spread of pest plants in the earliest phase, a goal which could be attained if the Caribbean community is informed of the problem.

South Florida has a recent history highlighted by the introduction of plant species from distant parts of the world. Some of these plant importations have proven to be extremely harmful to the natural environment and human infrastructure, this has instigated work toward a better description of the problem and control measures, if known. Concerned individuals in Florida were the first in the USA to organize a council to identify the most serious pest plants and compare notes on controls, if any. The Florida Exotic Pest Plant Council was established in 1984, and one of the early documents created was a checklist of the pest plants recognized at that time. Today, the list includes more than 120 species in two categories, based on oral and written field reports compiled from a wide spectrum of observers (FLEPPC 1996, 1999). Category 1 plants are considered the most serious, since these are defined as "Species that are invading and disrupting native plant communities in Florida." Category 2 species have "shown a potential to disrupt native plant communities."

An equally important issue is the effort to prevent the introduction of any new pest plants. Many researchers agree that one of the best predictors of invasiveness is invasive behavior documented elsewhere. Caribbean Islands and the Central American coastline share a large number of native and exotic plant species with Florida. For unclear reasons, many of the pest plants in Florida are just beginning to appear in the Caribbean, and

may become pests at least as serious as they are in Florida. There are enough signs to warrant thorough research and perhaps early control efforts.

The author's travels throughout the Caribbean region, sometimes in the company of expert botanists, coupled with a review of the most recent floras of the region, suggests that the disruption of native plant communities is in the earliest stages of development. Climatic or edaphic conditions, competition with other species, and existing predators may slow or arrest the explosive growth of some pest plant species, but it would be wise to eradicate the relatively small nuclei of the worst pest plants as soon as possible; the budget levels allotted to combat pest plant invasions in Florida will probably never be available in most Caribbean nations.

Bermuda has recently discovered the harmful effects of introduced exotics, and has successfully used the Florida EPPC list to evaluate species which are beginning to show pest plant behavior. This program of early recognition and prompt response is a model for other islands (Francis 1999.)

In the Bahamas, there are coastal and forest plant communities similar to those in South Florida, complete with many of the same invasive species: of the pest plant species listed for Florida, 29 of the 65 in Category 1, and 26 of the 58 in Category 2 occur in the Corrells' *Flora of the Bahamas Archipelago*, some with a warning of the incipient harm, based on the authors' observations of the species in Florida (Correll and Correll 1982). In addition to disruption of native plant communities, pest plants have been observed in habitats critical to endangered fauna. In the Bahamas, critically endangered Rock Iguanas (*Cyclura* spp.) are now restricted to small, rocky cays where they subsist on native plants, but need loose sand in which to dig nests for their eggs. Australian Pine (*Casuarina* sp.) has been observed with extensive, impenetrable root systems in the only sandy spot on one such cay, thus interfering with *Cyclura* reproduction (International Iguana Society Field Expedition, March 1992.) Brazilian Pepper (*Schinus terebinthifolius* Raddi) has been seen on other remote islands, and could also interfere with nesting sites. Near the airport on San Salvador Island, one small population of fruiting *S. terebinthifolius* was observed in June of 1994; it may still be possible to eradicate this species from this and other islands before the populations expand to unmanageable dimensions.

In the drier islands (Turks and Caicos group, St. Croix, etc.) or on dry sides of larger islands, Giant Milkweed (*Calotropis procera* (Ait.)Ait f. and Rubber Vine (*Cryptostegia grandiflora* R. Br.) are well established and spreading (Nellis 1997.) These highly poisonous plants add another dimension to the issue, as livestock or humans (including tourists) could be harmed by these unwanted plants.

In the Greater Antilles (Cuba, Jamaica, Hispaniola, and Puerto Rico), approximately half of both Category 1 and Category 2 of Florida's pest plants show up in recently published floras (Adams 1972, Liogier and Martorell 1982, Borhidi 1991.) Ironically, there are a few species considered native to the West Indies which appear on the EPPC lists, but this does not alter the argument against the other species. Similarly, some species native to Central America, such as *Mimosa pigra* L. and *Leucaena leucocephala* (Lam.) DeWit, have behaved as pest plants when introduced into the Caribbean islands.

In islands with significant agricultural production, the focus has been on unintentionally introduced crop weeds, but some pest plants are known to originate from ornamental introductions. Cuba has had a

longstanding problem with *Dichrostachys cinerea* (L.) Wight & Arn., a small thorny shrub introduced from Madagascar for its attractive flowers (Borhidi 1991.) This species (called "Aroma" in Cuba) infests many areas, displacing native plant communities and interfering with access to coastal sites. Unfortunately, *D. cinerea* is established in Florida, and has been found germinating in coastal strand of the lower Keys after the disturbance caused by Hurricane Georges in 1998 (Robert W. Ehrig, personal communication.) It is possible that the seeds for this most recent invasion were brought to Florida by the hurricane. The establishment of pest plants in the Caribbean has obvious implications for Florida, since the unrestricted movement of propagules by wind, water, and human transport is well known.

In Jamaica and Puerto Rico, the damage caused by pest plants may be more subtle. The exotic *Selaginella willdenovii* (Desv.) Baker has invaded the understory of some forests (Proctor 1985.) This species has long clambering stems and is displacing a wider diversity of native species. *Erythrina poeppigiana* (Walp.) O.F. Cook, was introduced from Peru as a source of quick shade, but is now spreading throughout many forests, perhaps replacing the native *Erythrina* species. Rose Apple (*Syzygium jambos* (L.) Alst.) is now a common component of the understory throughout the Caribbean, but probably passes unnoticed, thus allowing the species to become firmly established. Finally, rivers such as the Rio Cobre in Jamaica are choked with *Hydrilla verticillata* (L.f). Royle, but no attention is given to the problem (George R. Proctor, personal communication.)

In the Lesser Antilles, there are many pest plants now identified as "weeds," again with an emphasis on crop pests (Fournet and Hammerton 1991.) Some of these are well-known pests in Florida, but in stark contrast to the experience in Florida, *Melaleuca quinquenervia* (Cav.) S.T. Blake is known in the French Antilles as a pleasant ornamental which does not yet show invasive behavior. Still, approximately half of the Category 1 and half of Category 2 plants from the Florida EPPC list are included in the *Flora of the Lesser Antilles* (Howard 1992).

The nation of Belize is located on the Caribbean Coast of Central America, and is bordered to the north by Mexico and to the south and west by Guatemala. Formerly known as British Honduras, it has had a long history of British forestry activity, including the introduction of exotic species. Few exotics were noted in vegetation checklists published twenty years ago (Spellman *et al.*1975, Dwyer and Spellman 1981.) Today we can see *Casuarina* spp., *Gmelina arborea* Roxb., and Teak (*Tectona grandis* L. f.), all introduced as potential forest resources, but all of seemingly limited expansion at this time. Most recently, two species have come to light which could represent the earliest phase of pest plant invasion. Latherleaf (*Colubrina asiatica* (L.) Brongn.) an aggressive sprawling shrub, is now recognized as a severe problem in the southern coastal areas of Florida. One isolated population has recently been seen in a mangrove fringe in South Central Belize, where it has the potential to invade large areas, both natural and farmed (shrimp farms are currently the most important activities in this area.) It may not be possible to establish how and when the first plants arrived, but the current population is small enough to be easily eradicated. Australian Cajeput or Paperbark Trees (*Melaleuca* spp.) are evident in several regions of the country, and were certainly introduced as part of the early forestry activity. Records may exist with details of species used, origins, and planting sites. Until recently, the mature trees seemed to be confined to planted groves, and reproduction was not evident. One small population of old trees

(tentatively identified as *Melaleuca leucadendron*) on a coastal sand berm may be approaching the century mark, and despite the presence of capsules with seeds, no seedlings were found anywhere in the vicinity. Unfortunately, another population near the international airport has been observed to be reproducing rapidly, with many size class individuals spreading from a core population. Given the extensive seasonal savanna areas adjacent to this site, and knowing the behavior of a related species in Florida, we may be seeing the early phase of an invasion, which could easily be arrested before the cost becomes prohibitive, and before irreversible ecological damage is done.

This brief flyover of the lands of the Caribbean offers a glimpse of a new, underestimated ecological problem. In some cases, the results of ecological abuse or alteration are quickly made visible; in the world of plants, the changes are often slow and subtle, and may escape detection until the damage is extreme. For the people who live in the islands or mainland, there will always be questions of resource use and protection. In addition, social priorities may delay any response to the pest plant issue. Given our experience in Florida, it seems that the investigation of pest plants in the Caribbean is an ideal subject for educators, researchers, agencies, and others who have an interest in the health of the ecosystems and people of our nearest neighboring lands.

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Exotic Pest Plants in South Florida's Natural Areas

Tony Pernas
Everglades National Park
Homestead, Florida

Abstract

Exotic pest plants are having profound environmental consequences in south Florida. Melaleuca, Brazilian pepper, Australian pine, Old World Climbing fern as well as many other exotic pest plants are replacing native plant communities. Through coordinated efforts, the management of these species is possible, but extremely costly. Unfortunately, the alternatives are few. Failure to adequately address the exotic pest plant invasion may ultimately result in the loss of an ecosystem, forever changing the ecology of south Florida.

Discussion

'Exotic,' 'alien,' 'non-native,' or 'non-indigenous' are all terms that have been used to describe plants that are either deliberately or accidentally introduced outside of their native ranges by humans. Most exotic plants are not harmful. In fact, exotic plants form the foundation for agriculture. However, when an exotic plant is capable of detrimentally affecting native plant communities, the plant is labeled an exotic pest plant. Exotic pest plants are causing serious problems in natural areas through out the world. Exotic pest plants displace native vegetation, disrupt native plant communities by altering composition and function, reduce biodiversity, decrease the habitat needed for wildlife and can alter natural processes such as fire and water flow. Exotic pest plant's global threat to native biodiversity ranks second only to habitat loss (Vitousek et al. 1996).

In the United States (U.S.), exotic plant species are purposely introduced as ornamentals or for agriculture. Of these introductions, only about 5% become pests, but as the continued unregulated introduction of plants continues so will the risk of an accidental introduction of a serious pest. In Florida, over 900 exotic pest plant species have become established, comprising 27% of Florida's flora (Ward 1989).

The horticultural trade is responsible for the majority of the intentional introductions of exotic plants in Florida. Plants are usually selected for introduction because they possess certain attributes that make the plant an attractive choice for the consumer as well as for the propagator. These attributes can include rapid growth, lack of natural controls (diseases, parasites, and herbivores), abundant flowers/seed production, high seed

germination rates, and a rapid growth to maturity. These same attributes are also very typical of exotic pest plants.

Island ecosystems have been especially vulnerable to the impact of introduced exotic pest plants. This is due in part to their lower diversity of native plant species that allows exotic pest plants to successfully invade vacant niches. South Florida can be ecologically defined as an island as it is surrounded by water on three sides and by a frost line on the north. Of the 91species in Category I (species that are invading and disrupting native plant communities), 80 are found in south Florida (FLEPPC 1999).

Although south Florida's natural areas are plagued by hundreds of exotic pest plants, there are four species that have caused wide scale disruption: Melaleuca, Brazilian pepper, Australian Pine and Old World climbing fern.

Melaleuca — *Melaleuca quinquenervia*

Melaleuca, a native of Australia, was introduced into south Florida at the turn of the century as an ornamental and as a possible source of lumber. It can grow to 100 feet in height and forms dense forests that can crowd out native vegetation. Melaleuca is a problem species in Florida, Cuba, and the Bahamas. Melaleuca possesses several characteristics that have facilitated its spread throughout natural areas of south Florida:

- thick, fire insulating bark;
- high reproduction potential;
- a fire-triggered seed release mechanism;
- a high essential oil content which makes the tree highly volatile;
- storage of millions of seeds on a single tree for extended periods (average melaleuca tree produces 20,000,000 seeds);
- the production of adventitious roots;
- the ability to sprout from stumps and stems after felling; and
- lack of insect pests.

The uncontrolled expansion of melaleuca constitutes one of the most serious threats to the biological integrity of south Florida's ecosystem (Laroche 1999). Given its rapid spread rate, it has the potential to alter natural ecosystems by displacing native tree islands, sawgrass marshes, pine flatwoods, wet prairies and aquatic sloughs. If allowed to spread unchecked, melaleuca trees form dense monospecific stands that virtually eliminate other wetland species.

In 1994, melaleuca was estimated to infest 200,000 ha (490,000 acres) in south Florida. Infested acreage has been reduced by 100,000 acres as the result of the Florida Exotic Pest Plant Council's Melaleuca Management Plan (Laroche 1999).

In 1984, resource managers concerned over the spread of exotic pest plants, organized the Exotic Pest Plant Council (EPPC). The goal of EPPC was to establish an exchange of information on exotic pest plant biology, distribution and control. EPPC, prioritized Florida's exotic pest plants, and began developing comprehensive management plans. Through EPPC, the first management plan was developed in 1990. The Melaleuca Management Plan specified an integrated management of melaleuca, with specific goals and recommendations.

Integrated management of melaleuca requires the combination all available control methods including biological, mechanical, physical, and herbicidal. Seedlings are pulled and large trees are girdled or cut and then treated with herbicide. If conditions permit, treated areas are then burned or flooded to reduce post-treatment seedling establishment. In April 1997, the United States Department of

Agriculture released the first in a proposed suite of biocontrol agents that will assist land managers in slowing the spread of melaleuca.

Brazilian pepper — *Schinus terebinthifolius*

Brazilian Pepper, a native of Brazil, Argentina, and Paraguay, was introduced into south Florida in the late 1800s as an ornamental. Brazilian pepper is sometimes referred to as Florida holly because of the large amounts of red fruit, which is produced mostly in the winter. Brazilian pepper is a small tree with multi-stemmed trunks that grows to 30 feet in height. The seeds are spread by wildlife, primarily birds. It is now naturalized in over 20 countries; it is a problem species in Florida, Hawaii, and Bermuda. Brazilian pepper invades many natural areas including pinelands, hardwood hammocks, mangrove forests, and prairies. It is Florida's most widespread exotic, found on over 283,000 ha (700,000 acres) including over 100, 000 acres in Everglades National Park. A Brazilian Pepper Management Plan was produced by the Florida Exotic Pest Plant Council in July, 1997.

Australian pine — *Casuarina equisetifolia*

Australian pine, a native of Australia and the south Pacific islands, was introduced to Florida in the late 1800s. It has been planted extensively as a windbreak and a shade tree. It is a large tree reaching heights of over 150 feet. It readily establishes itself on beaches where the shallow rooted tree encourages beach erosion by displacing deep-rooted native species and interferes with the nesting of sea turtles and the American crocodile (Klukas 1969). The rapid growth of Australian pine coupled with its dense shade and extensive litter accumulation will lead to the displacement of native vegetation (Nelson 1994).

Old World Climbing Fern — *Lygodium microphyllum*

Old World Climbing Fern, a native of southeast Asia and Africa, is one of the most recent, yet most feared, exotic pest plants in South Florida by natural area managers because of its destructive potential, rapid rate of spread, and difficult and extremely costly control.
Old World climbing fern is native to Southeast Asia, Australia, and the Pacific Islands. It is wide-spread in the Old World tropics including Africa and Malaysia were it is considered a principal agricultural weed (Holm et al. 1979). This climbing fern with wiry rhizomes and climbing fronds is spread by airborne spores and is rapidly becoming one of south Florida's major exotic pest plants. It forms dense rhizome mats up to 3 feet thick on the ground and into tree canopies. This can cause management problems as fires are capable of climbing this ladder fuel into the canopy causing crown fires which can kill the fire adapted tree species. In Loxahatchee National Wildlife Refuge, *Lygodium* is now found in practically every tree island. *Lygodium* is believed to have been introduced into the Loxahatchee river area north of West Palm Beach in the 1950s. It is now found in nine Florida counties.

Exotic pest plants once they become established in natural areas are extremely difficult to control. Control typically involves labor intensive manual work that is extremely costly. Seedlings must be hand pulled, and larger plants treated with herbicide. This process usually occurs in remote areas with additional factors such as heat, high humidity, and insects that contribute to the difficulty.

A Note about FLEPPC Categories

The Florida Exotic Pest Plant Council developed a list of the most invasive exotic pest plants in Florida's natural areas. The FLEPPC list is maintained by a committee of botanists and land managers from government agencies, academia, and the private sector and is updated every two years. The list is divided into categories I and II. The definitions of these categories are:

Category I (91 species) — Species that are invading and disrupting native plant communities in Florida. This definition does not rely on the economic severity or geographic range of the problem, but on the documented ecological damage caused.

Category II (60 species) — Species that have shown a potential to disrupt native plant communities. These species may become ranked as Category I, but have not yet demonstrated disruption of natural Florida communities.

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Weedy Plant Issues Affecting Tropical Agriculture

Greg MacDonald
Agronomy Department, University of Florida
Gainesville, Florida

The Caribbean basin region comprises several islands and nations with a tremendous diversity of agricultural production, ranging from citrus and tropical fruits to vegetables and agronomic crops such as sugarcane, coffee, and pasture. This diversity coupled with the warm, humid tropical climate creates difficult and challenging weed problems.

One of the biggest issues in the tropical environment is continuous, year-long weed pressure. Most annual crop production occurs during the winter months, with reduced production in the summer months. However, the continuous pressure allows for weed problems to be maintained and exacerbated. In addition, most weeds have a tremendous growth rate due to the tropical climate and often comprise annual and perennial species. Furthermore, many annual species continue to perenniate due to the lack of frost. This often results in a brush-like annual species and a woody, tree-like perennial weeds.

Weeds impact tropical agricultural production similarly to production in subtropical climates. Weeds compete with the crop for essential water, nutrients, light, and physical space. They also impair harvest ability, both from a mechanical and labor standpoint. Many weeds are also toxic, once again impacting hand labor in the production and harvesting of the crop and also with possible contamination of poisonous by-products. The harvested product may also be contaminated with non-toxic but equally undesirable weedy plants that could dramatically affect the marketability of a commodity. Weeds also serve as hosts for a multitude of pests including insects, diseases and nematodes.

As mentioned previously, several weedy species cause serious problems in tropical production. Most of the species originate in tropical environments and are adapted to the environment. Such species include: ragweed parthenium (*Parthenium hysterophorus*), nutsedges (*Cyperus* spp.), amaranths (*Amaranthus* spp.), and several grass species (*Panicum, Brachiaria, Digitaria, Leptochloa,* etc.). Most of these species are annuals with C4 photosynthesis, rapid growth rate and prolific seed production which allow for rapid exploitation into an environment and tremendous competitive ability.

Agricultural production in the tropics has a multitude of problems associated with weed management and control. As mentioned previously, the first and foremost is the

constant pressure and tremendous rate of weedy plant growth. However, other factors directly associated with control in this region and environment cause severe problems. Production in these regions often have limited resources with regard to mechanization, chemical control measures (herbicides), and biotechnology. The lack of labor can be an important issue, particularly when resources in the previously mentioned areas are limiting.

There are several strategies with weed management in tropical agricultural production. Probably the most important is prevention. Clean, certified weed-free seed is necessary and steps to ensure seed production under these conditions is essential. Many companies use tropical regions for winter production of crop seed and this practice is vital to maintaining this industry in these areas. Practices to prevent the spread of weed seed are also key in limiting weedy problems. This should take into account spread from within a weedy area of a field to a clean area, spread from outside into a clean field and spread from a weedy field into an adjacent 'clean' field. These practices should include typical weeds but also care should be taken to prevent the spread and potential weediness of exotic crop plants. The best method of prevention is thorough sanitation, particularly of equipment and labor as it moves from field to field.

Mechanical weed control will continue to be an essential means of weed management. Such methods in mechanical control include primary tillage, mowing, and cultivation. These methods work extremely well, especially for perennial weed management. Continuous tillage will reduce or eliminate many perennial weeds and this may be the only viable option in certain woody crops. For example, perennial vines, grasses or shrubs in coffee may be impossible to control, but rotations that include a couple of years of annual crop production and vigorous tillage will eliminate these problems. Another very effective method of mechanical weed management is burning. Burning provides excellent weed control in many pasture situations and is a very useful tool in forestry. Flame cultivation has also been evaluated in cotton and may provide an option for weed control in many crops, but research is needed in these areas.

Chemical weed control with herbicides in tropical agriculture production will be a vital component of weed management but several factors need to be taken into consideration when using these materials and this type of approach. First and foremost, chemical weed control requires an extra level of management and some degree of precision. Familiarity with the activity of the materials to be used; selective vs. non-selective, soil vs. foliar application, contact vs. systemic are considerations that should be taken into account. Many tropical crops will response differently that more traditional row crops. Furthermore, the tropical environment (temperatures, humidity, light intensity) will affect herbicide performance and crop tolerance. Evaluations on herbicide performance should be conducted to avoid costly mistakes. Many of the soils in the tropics are vastly different and many tropical production systems rely on continuous cropping where herbicide persistence can be a major concern. Application technology in the form of hooded/shielded sprayers allow the use of non-selective materials to provide control of hard-to-control weedy species. These systems have excellent potential in tropical agricultural production.

Biotechnology has and will continue to change the way weeds are managed. These technologies have already had wide, sweeping impacts in traditional row crops and beginning to impact horticultural crops as well. Biotechnology thus far has involved genetically

manipulating (engineering) a crop plant to impart tolerance to a particular herbicide or to produce a specific insect toxin. This technology has the ability to revolutionize weed management but should not be treated as the 'cure-all' for weed control. Shifts and changes in weed spectrum will occur and in some cases resistence has been in an issue. In addition, several countries have banned the use and import of biotechnology crops, so care must be taken in marketing to avoid huge economic losses.

When using herbicides for weed management an important factor is the environmental impact of pesticide use. Many countries consist of a relatively small land area, with a fragile ecosystem that can be greatly impacted by minute changes in the environment. Care should be exercised when choosing and applying pesticides in these types of ecosystems.

Weed management in tropical agricultural production can be extremely difficult and several factors should be taken into consideration when developing weed control strategies. Tropical environments, more so than other areas, are dynamic environments with constant fluctuations in intensity and diversity of weedy species. Several factors will drive changes in these parameters including the type of production, method(s) of weed control, herbicide selection and the use of biotechnology. Care should be taken to rotate methods of weed control to avoid the dominance of one species and to prevent herbicide resistence. Weed management is not the driving force in many production systems but it is often the most time consuming and problematic for many people. It is also one of the most expensive production components and should be integrated with other production factors to develop a systems (IPM) approach.

The tropical environment has some of the greatest potential but also many of the most challenging problems including weed management. There are several key issues that aid in the success of a weed management program including prevention, rotation, and selection of weed control method(s), where integration with other production issues will determine the overall success or failure of an operation.

Biological Control of Some Exotic Weeds by Means of Insects

Julio C. Medal and James P. Cuda
Department of Entomology and Nematology
University of Florida, Gainesville

Abstract

Weeds are reducing yields in crops and replacing native vegetation in conservation areas. Chemical control and manual removal are the most commonly used weed management practices in agricultural ecosystems in Florida and the Caribbean region, respectively. The use of phytophagous insects as biological control agents of invasive weeds in rangeland, natural areas, and aquatic environments worldwide has increased significantly during the last decade. Invasive weed species such as purple nutsedge, spiny amaranth, purslane, and others could be suitable targets for biological control. A brief overview of classical biological control of weeds with insects in Florida is presented as well as prospects for biocontrol of weeds of the Caribbean region.

Introduction

Weeds are plants growing in places where they are not wanted. They can cause significant reductions in crop yields and displace native vegetation in pastures, rangelands and natural areas. Weeds can cause an average of up to 10% reduction in crop yields in developed countries, and an average of up to 20-30% crop yield losses, or even higher, in the Central American and Caribbean regions.

Herbicides and manual removal are the major weed management practices currently used in cultivated crops in Florida and the Caribbean region, respectively. Biological control of weeds, using mainly host-specific insects and to a lesser extent plant pathogens, has been traditionally practiced in developed countries such as the United States, Australia, Canada, South Africa, and New Zealand, primarily in rangeland situations, conservation areas, and aquatic systems. DeLoach (1997) defines biological control of weeds as "the planned use of undomesticated organisms (usually insects or plant pathogens) to reduce the vigor, reproductive capacity, or density of weeds .... it excludes cultural controls (grazing management, crop rotation, etc.) and natural control (the action of organisms without human direction)."

A frequently cited example of a successful biological control project is the control of prickly pear cactus, *Opuntia stricta* Haworth (Cactaceae) in Australia by the pyralid moth *Cactoblastis cactorum* Berg (Lepidoptera:

Pyralidae) introduced from Argentina in the 1920s. Another well-known example of classical biological control of weeds in the western United States is Klamath weed or St. Johnswort, *Hypericum perforatum* L. (Clusiaceae) by two European leaf-feeding beetles [*Chrysolina quadrigemina* (Suffrian) and *Chrysolina hyperici* (Forster)] imported from Australia in the mid 1940s. In Florida, complete biological control of alligator weed, *Alternanthera philoxeroides* (Mart.) Griseb. (Amaranthaceae) in aquatic environments was achieved by the introduction of a flea beetle, *Agasicles hygrophila* Selman and Vogt (Coleoptera: Chrysomelidae) from Argentina.

Interest in biological control of weeds using host-specific insects and pathogens has increased greatly in the last decade due to the public's concern about the negative effects of pesticides in the environment, a greater demand for pesticide-free agricultural products, the reduction of pesticide registrations, and the development of plant resistance to commonly used herbicides (Ahrens et al. 1981, Morrison et al. 1989, Powles and Howat 1990). Julien and Griffiths' (1998) world catalogue of biocontrol agents and their weeds lists 949 releases involving at least 350 organisms against 133 target weeds as of 1996. Forty-one (31%) of these weeds are considered under complete or substantial biological control.

Biological control is not a panacea and is not without an element of risk. The advantages of classical biological weed control are that it is highly specific to the target weed, it has little or no impact on non-target organisms, it does not pollute the environment, it is relatively inexpensive, and it provides self-sustaining and permanent control of the weed when it works. The disadvantages of biological control of weeds with introduced insects are that it is unpredictable, and even if the insects establish, biological control alone may not suppress the weed population enough to achieve the desired level of control. According to DeLoach (1997), several factors make biological control with insects even more difficult in field crops. First, disturbance from planting, cultivation, and pesticide applications is not conducive to biocontrol agent establishment. Second, because several species of weeds usually require control simultaneously, multiple biocontrol agents are needed. Finally, rapid control (usually within one month of planting) is necessary in order to prevent crop damage. Once weed-feeding insects establish, they are unlikely to build up damaging populations in a single field season. Highly specific plant pathogens are better suited to control weeds in field crop situations. Native plant pathogens can be formulated and applied as bioherbicides, or exotic pathogens can provide effective control of the weed following inoculative releases. Charudattan and DeLoach (1988) discuss the problems and opportunities associated with biological control of crop weeds.

Another constraint to the use of classical biological control of weeds involves conflicts of interest (Turner 1985). A plant that is perceived as a weed by one group of people can be considered a beneficial plant by another group. Beekeepers are a good example of a special interest group that may object strongly to biological control because they value the weed as a source of pollen and nectar.

Weed Biological Control Projects in Florida

Initial efforts on classical biological control of weeds in Florida were begun in the early 1960s by USDA-ARS researchers to control the South American aquatic plant alligator weed, *A. philoxeroides* (Buckingham 1994). One of the most effective natural enemies

introduced from Argentina to control this weed was the flea beetle, *A. hygrophila*. This insect was first released in 1965 in North Florida and its impact on the weed was so dramatic that in 1968 the U.S. Army Corps of Engineers discontinued all herbicide applications on alligator weed in Florida (Buckingham 1994).

The spectacular success of the alligator weed program stimulated increased interest and funding for biological control projects of other invasive aquatic weeds such as water hyacinth, *Eichhornia crassipes* (Mart) Solms-Laubach (Pontederiaceae), water lettuce, *Pistia stratiotes* L. (Araceae), and hydrilla, *Hydrilla verticillata* (L.f.) Royle (Hydrocharitaceae). Water hyacinth is native to South America and is considered the world's worst aquatic weed (Holm et al. 1977). The water hyacinth weevils *Neochetina eichhorniae* Warner and *N. bruchi* Hustache (Coleoptera: Curculionidae) were discovered in Argentina and first released in the United States in 1972 and 1974, respectively (Center 1982). The water hyacinth moth *Niphograpta* (= *Sameodes*) *albiguttallis* Warren (Lepidoptera: Pyralidae), also native to Argentina, was released in 1977 (Center and Durden 1981). In Florida, the combined impacts of these insects generally do not result in direct plant mortality but rather cause slower growth rates and eventually smaller plants that are highly susceptible to frost damage and fungal infections (Center et al. 1997a). However, dramatic reductions in water hyacinth coverage have been documented in other countries (Julien and Griffiths 1998).

Water lettuce is thought to be native to South America or the Old World tropics. This floating aquatic weed has become a serious problem in Florida since alligator weed and water hyacinth were effectively controlled. A tiny weevil *Neohydronomus affinis* Hustache (Coleoptera: Curculionidae) from Brazil was released against water lettuce in Florida in 1987 (Center et al. 1997a, DeLoach 1997). Although the weed was completely eliminated from three out of four of the original release sites in Florida within 18 to 30 months post-release, establishment and control at other sites where the weevil dispersed naturally has been inconsistent (Julien and Griffiths 1998).

Hydrilla is a submersed aquatic plant that was introduced into Florida waterways in the 1950s by the aquarium plant industry (Schmitz et al. 1991). Hydrilla could become the worst aquatic weed in North America because it has the potential to spread across the entire United States and into Canada. North American hydrilla plants probably originated in southern Asia although the plant's native range includes Australia and central Africa. Between 1987 and 1991, four insect natural enemies were released by USDA-ARS researchers in cooperation with the U.S. Army Corps of Engineers as possible biological control agents of hydrilla: two shore flies, *Hydrellia pakistanae* Deonier and *H. balciunasi* Bock (Diptera: Ephydridae), and two weevils, *Bagous affinis* Hustache and *B. hydrillae* O'Brien (Coleoptera: Curculionidae) (Balciunas et al. 1996, Grodowitz et al. 1996). Only the Asian hydrilla leaf-mining fly, *H. pakistanae,* is established in four states and has undergone significant range expansion (Center et al. 1997b). Small populations of the Australian hydrilla leaf-mining fly, *H. balciunasi,* are established in Texas, but this insect probably will have minimal value as a biocontrol agent for hydrilla in Florida (Grodowitz et al. 1997). The two *Bagous* weevils failed to establish in Florida because they require fluctuating water levels to complete their life cycles (Grodowitz et al. 1996).

In 1992, USDA researchers discovered that midge larvae were destroying the shoot tips of hydrilla in Crystal River, Florida (G.

Buckingham, unpublished data). The hydrilla at one of the sites exhibiting evidence of midge-feeding damage appeared short and unable to grow to the surface, a condition similar to that observed in Africa (Pemberton 1980). Since 1997, field and laboratory studies have been conducted to determine the biological control potential of this insect (Cuda 1998). The midge was recently identified as *Cricotopus lebetis* Sublette, a species of unknown origin that has not been reported from Florida (Epler 1995). The larvae of *C. lebetis* are bud miners that severely damage the apical meristems of hydrilla shoots. Pemberton (1980) speculated this type of damage would be desirable for control of hydrilla in Florida. Midge larvae feeding on the apical meristems could disrupt shoot growth and prevent the formation of the dense surface mats that are normally associated with typical hydrilla infestations. Approximately 70% of the plant's biomass is located in the top 0.5 meter of the water (Langeland 1990). If feeding damage by the larvae of *C. lebitis* can reduce the surface biomass, then most of the detrimental impacts associated with hydrilla may be eliminated.

Classical biological control research activities with non-native invasive trees such as paperbark tree, *Melaleuca quinquenervia* (Cav.) Blake (Myrtaceae) and Brazilian peppertree, *Schinus terebinthifolius* Raddi (Anacardiaceae) in south Florida started in the 1970s and 1980s, respectively. Melaleuca was introduced into Florida as an ornamental at the beginning of the 1900s (Turner et al. 1998). Infestations in south Florida have been estimated at approximately 2000 Km^2 (ca. 500,000 acres) of wetlands, mainly in the Everglades and in the Big Cypress areas (Bodle et al. 1994). Foreign explorations for potential biological control agents were initiated in the late 1970s (Habeck 1981). The first insect screened for melaleuca biocontrol was the leaf weevil *Oxyops vitiosa* Pascoe (Coleoptera: Curculionidae) which was released in April 1997, and its establishment has been confirmed in at least 13 locations in south Florida. The request for field release of a second agent, the melaleuca sawfly *Lophyrotoma zonalis* (Rohwer) (Hymenoptera: Pergidae), was submitted in November 1998. Release of this insect was approved by the USDA-APHIS, and it is currently undergoing an environmental assessment with final approval by the U.S. Fish and Wildlife Service pending. Another potential biological control agent is the melaleuca psyllid *Boreioglycaspis melaleucae* Moore (Heteroptera: Psyllidae). Host range studies of this insect have been completed at the Gainesville quarantine facility. USDA-ARS researchers have been trying to confirm that the damage observed in the melaleuca test plants is actually caused by feeding activity of the insects and not an unknown pathogen vectored by the psyllid (G. Buckingham, personal communication).

Brazilian peppertree was introduced into southern Florida as an ornamental tree in the 1840s and has become a serious weed of natural areas (Schmitz et al. 1991). Four insects were identified from exploratory surveys conducted in Brazil as potential biological control agents of Brazilian peppertree (Bennett and Habeck 1991). Two insect species, the thrips *Pseudophilothrips ichini* Hood (= *Liothrips ichini*) (Thysanoptera: Phlaeothripidae) and the sawfly *Heteroperreyia hubrichi* Malaise (Hymenoptera: Pergidae), were initially selected as candidates for further study because they visibly damage the plant in its native range and are probably host specific to Brazilian peppertree. Screening experiments conducted in Brazil and Florida have demonstrated that the sawfly *H. hubrichi* is highly specific to Brazilian peppertree (Medal et al. 1999c). The leaf roller *Episimus utilis* Zimmerman (Lepidoptera: Tortricidae), which was introduced into Hawaii for classical

biological control of Brazilian peppertree in the 1950s (Funasaki et al. 1988), is another insect that is undergoing further evaluation in the Gainesville quarantine.

The first terrestrial non-native pasture weed that has been targeted for biological control in Florida is tropical soda apple, *Solanum viarum* Dunal (Solanaceae). Tropical soda apple is native to South America, and it was first detected in south Florida in the mid 1980s. This perennial spiny plant has spread rapidly during the 1990s, and it has been found in eight other states. Cattle and wildlife (deer, raccoons, birds) feed on the ripe fruits and disperse the seeds to other areas. Surveys of natural enemies of tropical soda apple were started in June 1994 (Medal et al. 1996), and host range studies were initiated in December 1996 (Medal et al. 1999b). Exploratory surveys in the native range have revealed at least six insects that have potential as biological control agents of tropical soda apple (Medal et al. 1999a). Feeding tests with the leaf-feeding chrysomelid beetles (*Metriona elatior* Klug and *Gratiana boliviana* Spaeth) indicated these beetles have narrow host ranges and are capable of causing significant feeding damage to tropical soda apple plants (Medal et al. 1999a, b, unpublished data). Additional feeding tests with *M. elatior* were recommended by the Technical Advisory Group for Biological Control Agents of Weeds (TAG) and a request for field release in Florida will be resubmitted in September 1999. Feeding tests with *G. boliviana* will be completed later this year. Specificity tests with five other potential biocontrol candidates, a flower-bud feeder, *Anthonomus tenebrosus* Boheman (Coleoptera: Curculionidae), another leaf-feeder, *Platyphora* sp. (Coleoptera: Curculionidae), a leaf-roller (Lepidoptera: Pyralidae), a leaf-tier (Lepidoptera: Oecophoridae), and a stem-borer (Diptera: Agromyzidae), will be initiated when additional funds for overseas travel are made available.

Potential for Biological Control of Weeds in the Central-American and Caribbean Region

Recent successes with biological control of invasive weeds in non-crop and agricultural situations in other countries (Julien and Griffiths 1998) could be implemented in the low-input farms and conservation areas of the Caribbean Region. The complexity and diversity of agriculture practiced by farmers in the Central American and Caribbean regions suggest that weed management options should be biologically based (biological control using native or introduced insects and/or pathogens) and integrated with conventional control methods. For example, cultural practices (crop rotation, intercropping, plant density, non-tillage) that conserve the weed's insect natural enemies while affording a competitive advantage to the cultivated plants should be encouraged. Weed pathogens can be integrated with the more disruptive mechanical and chemical methods for high-cash crops or where the availability of manual labor is limited.

Several of the most serious weeds in Central America and the Caribbean region are *Cyperus rotundus* L. (Cyperaceae; known as purple nutsedge in the USA, coyolillo in Central America, coquito in Colombia), *Amaranthus spinosus* L. (Amaranthaceae; common name spiny amaranth in the USA, bledo in Central America), *Rottboellia cochinchinensis* (Lour) Chyton (Poaceae; known as itchgrass in the USA, La caminadora in Central America), *Sorghum halapense* L. (Poaceae; johnsongrass), *Bidens pilosa* L. (Compositae; mozote in Central America), *Sida rhombifolia*

L. (Malvaceae; escobilla in Central America), and *Portulaca oleracea* (purslane in the USA, verdolaga in Central America) (CATIE 1990, Zimdahl 1993, Salazar and Guerra 1996). The aforementioned weeds are appropriate targets for classical biological control because they are not native to the Caribbean region and they cause significant economic damage to justify the research costs. A diverse insect fauna (26 species) was found attacking *S. rhombifolia* in South America (Vogt and Cordo 1976). Several promising insect natural enemies were discovered attacking purple nutsedge, spiny amaranth, and johnsongrass from preliminary surveys conducted in southeastern Asia (DeLoach 1990). Thailand or Pakistan could be surveyed for natural enemies of itchgrass and purslane which also are native to southern Asia (DeLoach 1997). A biological control project for itchgrass using pathogens was recently initiated by CABI-United Kingdom and CATIE in Costa Rica.

The costs for implementing biological control programs in the Caribbean region can be significantly reduced via the short route, which makes use of existing technology that has been successful in other regions of the world (Harley and Forno 1992). In conclusion, biological control with insects and/or pathogens can provide an effective, safe and low cost solution to the Caribbean region's most important weed problems.

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Exotic Diseases: Threats to Tropical Fruit Production in the Caribbean Basin

Randy Ploetz
Tropical Research and Education Center, University of Florida
Homestead, Florida

Abstract

Plant diseases are among the most important constraints in agriculture. The numbers and types of new diseases that enter the Caribbean Region each year are probably exceeded only by the threat that is posed by other diseases that remain outside the region. This paper summarizes the current status of important exotic diseases of tropical fruit crops and the effects they would have on production should they enter the region. A plea is made for the compilation of a continuously updated database on the location of and threats that are posed by exotic diseases.

Agriculture is among the most important segments of most economies in the Caribbean region. For example, Florida ranks ninth in the United States in the value of its farm products (Anon. 1998). In 1997, these commodities were valued at over $6 billion and had a direct impact of over $18 billion on the state's economy.

Diseases impact the production of virtually all crops that are grown in the Caribbean, reducing yields and the pre- and post-harvest quality of these commodities and increasing the costs of production. In general, the region's warm, year-round temperatures and relatively high rainfall make diseases a more considerable problem here than in temperate production areas.

In this paper, I consider three different categories of plant diseases. In the first are the diseases that are mentioned above, i.e., those that are well-established in the Caribbean and already impact production. In a second category are diseases that remain outside the region, but threaten future production. Florida's renewed and costly battle with Asiatic citrus canker illustrates the serious nature of such a disease when it first arrives or, as is the case with this disease, is re-introduced into an area. The third class of diseases includes those that are not known or well characterized. Unfortunately, predicting or preparing for the arrival of such diseases is seldom possible. The recent rash of Geminivirus-induced problems on tomato are examples of such diseases (Polston and Anderson 1997). The whitefly *Bemisia argentifolia* colonizes tomato and is an effective vector of Geminiviruses. As it became established in the Western Hemisphere in the 1990s, outbreaks of Geminivirus-induced diseases on tomato increased dramatically.

New strains of these viruses that were not known previously on this or other crops caused many of these problems.

It is not clear whether the new tomato Geminiviruses originated via recombination of pre-existing strains or were moved from weed host reservoirs to tomato by the newly introduced vector. What is clear is that new (previously unknown) pathogens also pose significant threats to crop production in the Caribbean. Examining these interesting diseases is beyond the intended scope of this paper. Rather, I will restrict my comments to well-studied diseases of tropical fruit crops that have either recently arrived in the Caribbean or remain outside the region.

Tropical fruits are tremendously important crops throughout the Caribbean Basin (Table 1). They are valuable cash commodities, are the sources of vitamins and minerals, and some, such as banana, are staple foods for many in the region. The importance and general features of the selected diseases are reviewed below.

Banana

Since plantain is actually a type of banana, both fruits will be referred to collectively in this paper as simply banana. Banana, *Musa* spp., is one of the most popular of all fruits, and is among the world's most important food crops. After rice, wheat, and milk, it is the fourth most valuable food. In export, it ranks fourth among all agricultural commodities and is the most significant of all fruits, with international trade totaling $2.5 billion annually. Of the 86 million tons of fruit that are produced in the world each year, about 2.8 million tons originate in the Caribbean (Anon. 1999b). Much of this fruit is exported to Europe (most often from former colonies) and is responsible for significant portions of the export economies of many of these countries. For example, in 1997, 59% of the foreign trade of St. Lucia came from exported bananas (Anon. 1999a). Each of the three diseases that are described below have the potential to severely cripple export and domestic production throughout the Caribbean.

Banana bunchy top — Bànana bunchy top is the most important virus-induced disease of banana, and is a major constraint to production in many areas (Dale 1987). The total elimination of banana production by bunchy top in some areas of Pakistan illustrates the destructive capabilities of this disease (Soomro and Khalid 1993).

Banana bunchy top was first recorded in Fiji in 1879, and is now found throughout the Pacific (Guam, Hawaii, Tonga, and Western Samoa), Asia (China, India, Indonesia, Pakistan, Philippines, Sri Lanka, Taiwan, and Vietnam), and Africa (Burundi, Egypt, Gabon, Malawi, Rwanda, and Zaire) (Ploetz 1998). It is incredibly fortunate (lucky?) that this disease has not reached the important export-producing countries in Central and South America.

The first symptoms of bunchy top are dark green streaks on the petiole of the newly emerging leaf (Dale 1987). The streaks, that are also known as "Morse-code" symptoms, are delimited by the leaf veins and are of varying length. These symptoms must be recognized early in the development of this disease in order for it to be effectively managed (see below). As the disease progresses, internode length decreases, and leaves become smaller and upright. Depending on when the plant is infected, bunches are either not produced or do not emerge from the stem.

Banana bunchy top is caused by a virus which contains a circular, single-stranded (ss)DNA,

the banana bunchy top virus (BBTV) (Harding et al. 1991, Thomas and Dietzgen 1991). *Musa acuminata*, *M. balbisiana*, *M. acuminata* x *balbisiana*, and *M. textilis* are natural hosts of BBTV, and *Ensete ventricosum* has been experimentally infected.

BBTV is transmitted by the banana aphid, *Pentalonia nigronervosa* (Dale 1994). The aphid occurs in all major banana-producing regions, and accounts for the short-distance spread of banana bunchy top, particularly within a plantation. Long-distance spread is due to the movement of infected planting material (rhizomes and suckers). Unlike diseases that are caused by fungi, bacteria, and nematodes, BBTV is carried in micropropagated plants. Thus, new germplasm should be indexed for the virus before it is introduced into a new area.

There is no known resistance to banana bunchy top in banana (Dale 1994). To date, effective control measures have been based on quarantines and santitation. Quarantine originally relied upon the visual inspection of introduced plants for symptoms, a less than reliable means for identifying infected plants. Recently, serological and DNA-probe techniques that have been developed have proven to be much more reliable than visual identification, and these techniques are now used routinely to index tissue-cultured germplasm.

Once bunchy top is found in an area, it is managed by identifying infected plants when they first exhibit symptoms. These, and all other plants in the surrounding mat, should first be treated with an aphidicide to kill the banana aphid vector and then removed from the plantation and burned. In Australia, where stringent laws have been passed and are strictly enforced, these measures have resulted in excellent control of this disease (Dale 1994).

Black Sigatoka — Worldwide, two leafspot diseases of banana are most significant, yellow Sigatoka and black Sigatoka. Although they affect banana in very similar ways, black Sigatoka is much more important. It occurs in several locations in the Eastern Hemisphere, and throughout Mexico and Central and South America. In the Caribbean, the disease has spread to Cuba (1992), Hispanola (Dominican Republic) (1996), and Jamaica (1994), and was found in southern Florida in 1998 (Ploetz and Mourichon 1999, (Tejerina et al. 1997). Since it will almost certainly continue to spread in the Caribbean, it poses a very great threat to export trades that are found in the Windward Islands as well as production for local consumption in all of the islands.

Black Sigatoka affects a wide range of cultivars and can completely defoliate highly susceptible cultivars before the fruit bunch is mature (Fullerton 1994). It attacks plantain cultivars and cooking bananas that are important food sources in the Caribbean and which are scarcely affected by yellow Sigatoka. Fruit from affected plants ripen prematurely (a serious defect in exported fruit), finger size, and number is reduced, and overall yields are reduced by 50% or more. The disease is especially important where growers cannot afford chemical control measures.

Reliable identification of yellow and black Sigatoka is often difficult, especially in the early stages of development. In general, the thickened scars on conidiophores and conidia of the black Sigatoka agent, *Mycosphaerella fijiensis* (anamorph: *Paracercospora fijiensis*), are absent in the yellow Sigatoka agent, *M. musicola* (anamorph: *Pseudocercospora musae*) (see Fullerton 1994 for complete descriptions of these pathogens). The greater abundance of stromata and conidia of *M. fijiensis* on the lower and of *M. musicola* on the upper surface of lesions also helps distinguish these diseases. Recently, molecular

techniques have been described for identifying the fungi in culture and infected leaf tissue (Carlier et al. 1994, Johnson et al. 1994).

Black Sigatoka is readily disseminated via ascospores of *M. fijiensis* in air currents which are capable of traveling long distances. However, long-distance spread is most effectively accomplished via the movement of infected planting materials. Circumstantial evidence indicates that a hobbyist who brought in infected rhizomes was probably responsible for the recent black Sigatoka outbreak in southern Florida, and it has been suggested that the initial outbreak on Cuba resulted from the movement of suckers to the island from Nicaragua. Since this will likely be the way in which the disease is spread to other islands in the Caribbean, it is imperative that the movement of traditional seedpieces of this crop within the region be restricted.

Chemical control measures are needed to produce fruit of susceptible cultivars in areas that already have the disease (Fullerton and Stover 1990). These measures are based on the application of protectant or systemic fungicides, often in combination with mineral oil. Mineral oil has fungistatic properties and increases the effectiveness of most fungicides. Depending on the frequency of rainfall and whether disease monitoring and forecasting techniques are used (these are standard practices in export plantations), the annual number of fungicide applications can range as high as 40. In contrast, resistant cultivars provide the most practical means of control in small-scale production (Jones 1994).

Race 4 of Panama disease — Panama disease (fusarium wilt) of banana was first recognized in subtropical Queensland, Australia in 1874 (Bancroft 1876). It is now found in essentially every banana-growing region except the Mediterranean countries, Somalia, and the South Pacific (Ploetz and Pegg 1997, Stover and Simmonds 1987). Panama disease has already limited the production of several different cultivars in South Florida (Ploetz et al. 1999, Ploetz and Shepard 1989).

Four races of the causal agent, *Fusarium oxysporum* f. sp. *cubense*, are recognized, three of which affect banana (Ploetz 1994). Race 3 affects species of Heliconia, and is not an important pathogen of banana (Waite 1963). Race 1 affects dessert cultivars such as 'Manzano' ('Silk'), and race 2 affects 'Bluggoe' and related cooking bananas. Race 4 affects a very wide range of cultivars, including those in the 'Cavendish' subgroup and race 1 and race 2 suscepts. Although races 1 and 2 are widespread in the Caribbean Basin, race 4 is currently restricted to the Eastern Hemisphere. Due to its wide host range and aggressiveness, race 4 would devastate production if it ever reached the Caribbean.

Fusarium wilt is a soil-borne, lethal disease. Internal symptoms include a conspicuous reddish-brown discoloration of the xylem in rhizomes and the pseudostem. Externally, leaves become bright yellow, starting first with the oldest leaves. Eventually, leaves wilt and collapse around the pseudostem, giving the plant a skirted appearance. Green leaves may also collapse and leaf sheaths at the base of the pseudostem often split.

The pathogen is capable of prolonged survival in soil, either in previously colonized host tissues as chlamydospores, or as a parasite of weed hosts (Ploetz 1994). Usually, susceptible cultivars cannot be grown in an infested site for up to 30 years (Stover 1962).

Fusarium oxysporum f. sp. *cubense* is most frequently spread in infected rhizomes. Since suckers are often symptomless when infected, producers can unknowingly move the pathogen within and among plantations. The pathogen also moves within root systems of

interconnected mats, in soil, running water, and on infested tools and machinery.

When susceptible cultivars are grown, pathogen-free rhizomes and noninfested soil are essential. Whenever possible, tissue-culture plantlets should be used as pathogen-free sources of planting material.

Fusarium wilt cannot be controlled with fungicides, and soil fumigants provide only temporary control (Herbert and Marx 1990). Genetic resistance is a most effective control measure (Jones 1994). In general, good sources of resistance are found among pre-existing cultivars of most types of banana. New sources of resistance are also available from the breeding programs. For example, 'FHIA 01' (also known as 'Goldfinger'), from the Fundación Hondureña de Investigación Agrícola in La Lima, Honduras, is resistant to all known variants of the pathogen.

Citrus

Citrus, *Citrus* spp., is an ancient crop that is believed to have originated in Southeast Asia (Davies and Albrigo 1994). It is now grown throughout the world between 40° north and south latitudes. Several different species and hybrids are grown commercially for fresh fruit, juice, and other products. World production exceeded 102 million tons in 1998, of which ca. 14 million and 1 million tons, respectively, were produced in Florida and the islands of the Caribbean, respectively (Anon. 1999b) (Table 1).

Citrus greening — Greening is one of the most destructive diseases of citrus (Garnsey 1988). It probably originated in China where it is known as "huang long bing" (yellow dragon disease) in reference to the general chlorosis it induces. Other descriptive names for the disease include leaf mottling in the Philippines and vein-phloem degeneration in Indonesia. Greening is now found throughout Asia and Africa, but has not been reported in the Western Hemisphere.

Greening is vectored in Africa by the African citrus psyllid, *Trioza erytreae*, and in Asia by the Asian citrus psyllid, *Diaphorina citri*. Development of the disease in Africa is optimum at 20–24°C, but develops at higher temperatures (up to 32°C) in Asia. Laflèche and Bové (1970) consistently associated a phloem-limited prokaryote with greening in sweet orange. They thought the organism was a mycoplasma-like organism (phytoplasma), but it was shown later by Jagoueix et al. (1994) to be a rod-shaped, Gram-negative bacterium in the α-subdivision of the class Proteobacteria. Recently, the African and Asian bacteria were tentatively named, respectively, *Liberobacter africanum* and *L. asiaticum* (Jagoueix et al. 1997).

Neither bacterium has been cultured, but the disease and bacteria have been transmitted to citrus via grafting and with dodder (Garnier and Bové 1983). Although natural spread occurs via the psyllids, they are not very effective vectors (Garnsey 1988). In general, high populations of the insects are required for epidemic development of the disease to occur.
The greening agents can infect most species of Citrus, and sweet orange, mandarins and mandarin hybrids are highly susceptible (Garnsey 1988). Since they are transmitted via infected scion material, successful management of the disease requires the use of clean propagation materials; hot water treatment or the use of shoot-tip grafting are used conventionally.

In June 1998, the Asian vector, *D. citri*, was discovered in Palm Beach County, Florida (Halbert, personal communication). Eventually, the insect will move throughout

citrus-producing areas in Florida. Even though recent assays of populations of *D. citri* in the state have been negative for the greening agent, the establishment of this vector in the state will hasten the spread of greening if it is ever introduced into Florida.

Coconut

Coconut, *Cocos nucifera*, is one of the most widely distributed and important crops in the tropics (Persley 1992). It has been variously called "the tree of life," "the tree of heaven," and "mankind's greatest provider in the tropics." Virtually every part of the tree is used. It provides food, drink, oil, medicine, fiber, timber, thatch, fuel and domestic utensils. In addition, it is an esteemed ornamental palm.

The coconut probably originated in Melanesia, but it now has a pantropical distribution. About 85% of the annual global output of 48 million tons is produced in Asia. Although only 1% of this total is produced in the Caribbean, coconut is still an important crop and tree in most countries in the region.

Cadang-cadang of coconut — Cadang-cadang is a lethal disease of coconut palm that was first reported in the Philippines in the 1930s (Randles et al. 1994). The disease is found in the central Philippines, and a similar disease, tinangaja, occurs in Guam (Hodgson et al. 1998).

Cadang-cadang develops quite slowly. During the early stage of development (2–4 years in length), nuts become rounded and develop equatorial scarifications, and leaflets in the lower portion of the canopy develop small, translucent yellow spots. In the mid-stage (2 years), inflorescences become necrotic, nut production ceases, new frond production slows and leaf spots become larger and more frequent. In the late-stage (5 years), leaf spots are almost confluent, the crown appears chlorotic, and fronds are reduced in size and number. The disease progresses more rapidly in younger palms, but rarely develops before flowering.

Cadang-cadang is caused by a circular, single-stranded RNA, the coconut cadang-cadang viroid (CCCVd) (Hanold and Randles 1991a). Viroids related to the cadang-cadang agent are widely distributed in many countries in coconut, oil palm, and other tropical monocotyledons, but typical cadang-cadang disease has not been recognized outside the Philippines (Hanold and Randles 1991b).

Cadang-cadang is diagnosed by analyzing plant samples with polyacrylamide gel electrophoresis (PAGE) and purified CCCVd as a size marker (Randles et al. 1994). Sequences related to CCCVd are identified in leaf samples by electroblotting gels onto nylon membranes and probing for viroid sequences with complementary radioactive RNA. With this technique, sequences that are related to CCCVd have been detected in coconut, oil palm, and other tropical monocots outside the range of cadang-cadang. Although oil palm that is infected with such sequences frequently shows orange leaf spots, other species do not exhibit specific symptoms.

It is not known how cadang-cadang spreads in nature (Randles et al. 1994). The distribution of diseased trees in a plantation is essentially random. The incidence of disease varies greatly among regions, and the annual rates of increase range from 0.1% to 1%.
CCCVd can be detected in pollen, husks, and embryos of coconut, and the rate of seed transmission of cadang-cadang is about 0.3%. Clearly, the movement of germplasm between countries should be regulated (Frison and Putter 1992). Since symptoms do not reliably diagnose the disease, molecular techniques should be used to index germplasm for

CCCVd. Leaves of pollen source trees must be indexed when pollen is collected, and pollination should await the indexing results. Embryos that will be moved should be excised from premature nuts, germinated in vitro and indexed prior to release. Likewise, seed nuts should be germinated and indexed before shipping.

No resistant selections have been found, and no means for controlling spread in plantations are known (Randles et al. 1994). However, since the disease develops slowly and the rate of spread is not significantly influenced by the proximity of diseased palms, production is often extended in affected plantations by planting replacement seedlings beneath diseased trees.

Red ring of coconut — Red ring of coconut is a serious, lethal disease in the Western Hemisphere (Giblin-Davis 1994). It was first described in Trinidad in 1905, and is now found from Mexico to northern South America and in the southern Caribbean. At least 16 other species of palm are known to be hosts, the most important of which are *C. nucifera*, the African oil palm, *Elaeis guineensis*, and the date palm, *Phoenix dactylifera*.

Symptoms vary widely with environmental conditions and the species, age, and cultivar of palm that are affected (Giblin-Davis 1994). Palms younger than 1½ years old cannot be infected experimentally with the causal nematode, and red-ring disease has not been recorded from palms of this age in the field. In coconut palm, symptoms include premature abortion of nuts, deterioration of inflorescences, and chlorosis and death of younger and younger leaves. Leaf yellowing usually starts at the tips and moves towards the petiole base. Dying leaves may break close to the petiole and remain hanging from the stem. In stem cross sections, a brick to brownish-red ring, 2–6 cm wide, is evident 2–6 cm within the stem periphery. The leaf petioles and cortex of roots can also be discolored yellow to brownish-red. In longitudinal section, discoloration is usually continuous throughout the length of the stem, appearing as two bands which unite at the base and form discontinuous lesions near the crown. Three- to ten-year-old palms usually die within 2–4 months of infection, but trees more than 20 years old suffer a prolonged death.

The causal nematode, *Bursaphelenchus cocophilus* (formerly *Rhadinaphelenchus cocophilus*), was identified and described in 1919 (Gerber and Giblin-Davis 1990). Diagnostic features of the nematode are listed by Giblin-Davis (1994). It appears to be an obligate parasite of many palm species and is vectored by adults of the American palm weevil, *Rhynchophorus palmarum*, and, possibly, the palm weevil, *Dynamis borassi*.

Phytosanitation, directed at reducing the vector population as well as the number of sources of the nematode, is currently the best method of red-ring management. As soon as palms with symptoms are detected they should be destroyed. In coconut, the disease can be confirmed by extracting nematodes from stem tissue with a coring device. Infected trees should be killed with herbicide and, if heavily infested, treated later with an insecticide. The effectiveness of pesticide traps treated with semiochemicals and *R. palmarum*-specific pheromone are being investigated (Giblin-Davis 1990).

Mango

Mango, *Mangifera indica*, is one of the world's most prized fruits. Most mangos are consumed as fresh fruit, although a small proportion are processed for juice, nectar, puree, and preserves. They are a good source of vitamin C and provitamin A.

Mango is grown throughout the subtropics and tropics and is one of the world's most important fruit crops. About 70% of the world's annual production of 23.5 million tons comes from India, but Mexico is the world's largest exporter (Anon. 1999b). About 2% of the world output comes from the Caribbean.

Bacterial black spot of mango — Bacterial black spot is a destructive leaf, stem and fruit disease of mango (Manicom and Pruvost 1994). In India, the disease is called bacterial canker due to the lesions it causes on the stems of some cultivars (Prakash et al. 1994). To date, it has been confirmed in: Asia (India, Japan, New Caledonia, Pakistan, Philippines, Taiwan, and Thailand); Africa (Comoros, Mauritius, Reunion, Rodrigues, South Africa); Australia; and South America (Brazil) (Fukuda et al. 1990, Gagnevin and Pruvost 1995). Nonconfirmed cases have been observed in several other locations throughout the tropics (C.W. Campbell, personal observations, Kishun 1995, Prakash et al. 1994). Given the disease's wide distribution, the ease with which the pathogen is disseminated in scion material, and its long history of importing new germplasm, it is surprising that this disease is not already found in the Caribbean.

Bacterial black spot is caused by *Xanthomonas campestris* pv. *mangiferaeindicae*. Early reports of the disease listed either *Pseudomonas mangiferae-indicae* or *Erwinia mangiferae* (synonym: *E. herbicola*) as the incitant (Patel et al.1948, Steyn 1974). Cook (Cook 1975) indicated that the latter bacterium reaches high populations in old lesions, but that it is a saprophyte.

Characteristics of the causal bacterium were published by Manicom and Wallis (1984). It has a single flagellum and is Gram-negative, rod-shaped and 0.4–0.5 × 1.0–1.5 mm. Colonies are white to cream-colored on artificial media. However, yellow-pigmented bacteria, typical of other xanthomonads, are also recovered from symptomatic tissues and may con fuse diagnosis of this disease. Reliable identification of bacterial black spot and the causal bacterium rely on pathogenicity tests.

Strains of the pathogen from different production areas around the world are quite diverse (Gagnevin and Pruvost 1995, Kishun 1995). Recent analysis of a worldwide population of 139 strains from 14 countries indicated that genetic diversity was greatest among strains from Southeast Asia, suggesting that this region of host diversity was also a center of pathogen diversification (Gagnevin and Pruvost 1995). Groups of genetically similar strains were usually found in only one or two countries. However, the largest group of strains was found in at least nine different areas, leading the authors to conclude that it may have been disseminated worldwide from a single source.

Symptoms can develop on leaves, stems and fruit, but are found first on leaves. They appear as tiny, water-soaked spots, 1–3 mm in diameter, are delimited by veins, and often coalesce to become black and slightly raised. Leaf lesions exude gum in humid conditions, and become gray, dry out, and crack as they age. Stem lesions appear as longitudinal fissures that also exude gum, and usually form in only the most susceptible cultivars. Fruit lesions develop as watersoaked halos around lenticels or wounds, and soon become raised, blacken and crack open to exude gum. They vary from 1–15 mm in diameter, and can extend to a depth of 8–15 mm into the flesh rendering the fruit unmarketable.

The angular and raised appearance of the leaf lesions distinguishes them from the flat and somewhat rounded lesions caused by *Colletotrichum gloeosporioides*. They are also distinct from lesions caused by a recently observed disease in Florida that are apparently

caused by a different strain of *X. campestris* (M.J. Davis, unpublished). Although these lesions are black and delimited by leaf veins, they are not raised and do not form on branches and fruit.

Xanthomonas campestris pv. *mangiferaeindicae* is an epiphytic colonist of leaves (Manicom 1986), buds (Pruvost et al. 1993) and fruit (Pruvost and Luisetti 1991) of mango. In addition, the pathogen can colonize and be disseminated in fruit pits (Prakash et al. 1994). Although damage is greatest on young mango trees, young leaves are not infected. The pathogen usually infects old leaves through wounds and, less often, stomata. It is disseminated during rainy weather, and infection is enhanced when rains occur in concert with winds that promote wounding of the leaf surface. Disease development is favored by high relative humidity (> 90% RH) and moderate temperatures (25–30°C) (Pruvost and Luisetti 1991).

Bacterial black spot is difficult to control on susceptible cultivars (Manicom and Pruvost 1994). During rainy weather, applications of copper-based bactericides are recommended. Agricultural antibiotics have been reported to be effective, but resistance problems that develop after continuous use of these products limits their long-term effectiveness against this disease. In general, resistant cultivars should be used in disease-prone areas, in addition to the use of windbreaks, to reduce wounding, and the removal of symptomatic portions of trees.

Conclusion

Excluding exotic diseases from the Caribbean is an ambitious objective, and all but the most optimistic person would conclude that it would be impossible to effectively exclude all of those that threaten the region. Travel within and to the Caribbean will continue to increase in the future, as will international trade, and manpower and monetary constraints will surely continue to reduce the efficacy of exclusion efforts. The complexity and grave nature of the situation in the United States illustrates the magnitude of this problem in the region as a whole (National Plant Board 1999). Over 300 international ports of entry now exist in the United States, only some of which have APHIS inspectors on duty 24 hours a day. Even in these locations only a small percentage of the illegal materials that enter are ever found. Although a change of the current focus on port-of-entry inspections to point of origin mitigation will likely decrease the flow of such contraband into the country, in the final analysis it is doubtful that these leaky borders could ever be completely sealed to exotic pests: highly effective measures, were they available, would probably be so expensive that they would not be tolerated politically.

A useful step towards improving exclusion efforts in the Caribbean Region would be the creation of a current and continuously updated listing of exotic diseases and the causal agents, their geographic distributions, and the risk of their spread to and within the region (see National Plant Board 1999). A brief outline of the types of information that might be included in such a list is included for the above diseases in Table 2. Australia and New Zealand already have comprehensive lists in place, and they are models to which APHIS looks when it contemplates overhauling its protective measures.

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Table 1. Production Statistics for Selected Tropical Fruit Crops in Florida and the Caribbean Basin *

Fruit	Florida			Carribean Basin	
	Hectares	Gate value ($million)	Tons (1,000s)	Hectares (1,000s)	Tons (1,000s)
Banana + Plantain	141	2.56	2	287	2,782
Citrus	338,000	1,556	13,700	169	1,280
Coconut	22	0.28	na	109	420
Mango	834	1.72	na	68	517

* Production figures for Florida are for 1997, from Crane (7), Degner et al. (11), and C. Balerdi (personal communication), and for the Caribbean are for 1998 and are from the FAOSTAT on-line database (3).

Table 2. Modes of Dissemination and the Risk of Movement of Important Tropical Fruit Diseases into and within the Caribbean Basin

Disease	Primary means of long-distance spread	Current distribution	Risk of spread [1]	
			Into region	Within region
Banana bunchy top	Infected seedpieces	Africa, Asia, Australia, Hawaii, South Pacific	High	High
Black Sigatoka	Infected seedpieces	Africa, Asia, Cuba, Dominican Republic, Florida, Jamaica, Tropical America	Already present	High
Race 4, Panama disease	Infected seedpieces	Asia, Australia	Moderate	Moderate
Citrus greening	Infected rootstocks, scions	Africa, Asia	Moderate	High
Coconut cadang-cadang	Seed [2]	Philippines	Probably low	Probably low
Coconut redring	Vector movement	Southern Caribbean, Northern tropical America	Already present	Moderate
Mango bacterial black spot	Infected planting material	Africa, Asia Australia and Brazil	High	High

1) The evaluation of risk includes the following considerations: 1) value of the affected commodity, 2) ease with which the disease's causal agent moves long distances, and 3) the amount of international travel and trade between the Caribbean and the currently affected areas.

2) The means by which natural spread of cadang-cadang occurs within plantations is not known, and the rates of seed transmission is low (ca. 0.5%).

Arthropod Pests Threatening Tropical Crops in Florida: How Can Their Impact Be Avoided?

Jorge E. Peña and Richard M. Baranowski
Tropical Research and Education Center, University of Florida
Homestead, Florida

Abstract

Florida's prominent position on the Caribbean region and Gulf of Mexico, favorable climate, popularity among tourists, and abundant tropical fruit crop production make it particularly vulnerable to exotic pests. During the last 10 years several pests have added significant costs to tropical fruit, vegetable, and ornamental production. They include among others, the citrus leafminer (*Phyllocnistis citrella*), citrus root weevil (*Diaprepes abbreviatus*), melon thrips (*Thrips palmi*), banana moth (*Opogona saccharalis*), and cycad scale (*Aulacaspis yasumatsui*). Other pests that are a threat to Florida tropical fruits include the pink mealybug (*Maconellicoccus hirsutus*), avocado weevils (*Conotrachelus aguacatae*, *Heilipus lauri*), the avocado moth (*Stenoma catenifer*), the litchi mite (*Aceria litchi*), and the fruit fly (*Bactrocera carambolae*). Understanding the biology and characteristics of these pests may help understanding principles of their control, thus avoiding unnecessary environmental and economic costs.

Introduction

Florida's prominent position in the Caribbean, tropical climate, popularity among tourists, international commerce and tropical agriculture make it particularly vulnerable to exotic pests. While most introduced species fail to become established, those that do can become serious pests of agricultural crops. These species cost Florida and the countries where they are established billions of dollars annually in control measures and crop damage. For example, the root weevil (*Diaprepes abbreviatus*) which was introduced from the Caribbean into Florida 30 years ago, cost approximately 72 million dollars to citrus growers alone. Species that would likely invade and become pests would be those with high rates of growth, maturation, and reproduction over a wide range of environmental conditions (Venette 1997). Invasions are most likely to succeed in sites that are highly disturbed or have a climate similar to that from which the pest originated. Even though "disturbed sites" are difficult to define, those systems where the numbers of natural enemies are reduced would be more vulnerable than those where there are less disturbances. Tropical fruit pests, such as the destructive pink mealybug (*Maconellicoccus*

hirsutus), the carambola fruit fly (*Bactrocera carambolae*) are examples of pests that are a threat to tropical fruits (Table 1). Vegetable and ornamental pests, such as the European violet gall midge (*Dasineura affinis*) and the South American tomato pinworm (*Tuta (Scribopalpula) absoluta*) are examples of pests that threaten ornamentals and vegetables. The objectives of this paper are 1) to elucidate some characteristics of these pests that affect tropical fruit, vegetable, and ornamental crops in neighboring areas and are a threat to the tropical agricultural industry of Florida and 2) to describe some of the problems that the authors perceive as handicaps for a successful program against invasive pests.

Potential Pests

***Maconellicoccus hirsutus* (Green)** — The pink mealybug, hibiscus mealybug, or grape mealybug, has been previously reported as *Pseudococcus hibisci* Hall or *Phenacoccus hirsutus* Green. Its original distribution is in the oriental, Australian , Palearctic, and Ethiopian regions (Mani 1989). It has also been reported from Pakistan and some Pacific islands including Hawaii and Guam (Ghani and Muzaffar 1974; Beardsley 1985, 1986). It was first identified in the Caribbean in Grenada in November 1994, first recorded in Trinidad in June 1995 (McComie 1995), and by 1996, it was found in St Kitts. Latest reports in 1998 are from Guadeloupe (Etienne et al. 1998). *Maconellicoccus hirsutus* is an extremely polyphagous species. Affects at least 74 plant families, about 144 genera. Some major hosts include mango, hibiscus, palms, coffee, grape, citrus, and *Annona* spp. *M. hirsutus* caused losses to landscape and fruit trees in Egypt (Hall 1926), and Williams (1985) noted that it caused bunchy leaves on lime in Australia. The tropical fruit crops in the Caribbean that are affected include *Annona* spp., carambola, litchi, mango, avocado, *Citrus* sp., bananas, and papaya. The development of this species occurs in 3–4 weeks, and the females can produce approximately 500 eggs each (Ghose 1972). Work by Ghose (1972) demonstrated only sexual reproduction. During late autumn and winter, the female seeks a sheltered position to lay her eggs, usually ending in a gathering of similar females. In the summer, females may not seek shelter to lay eggs. Eggs hatch in 3–8 days (Ghose 1972; Misra 1919) and the nymphal stage lasts 10–22 days (Mani 1986). Infestation symptoms appear first on the growing points. Shoots become twisted with shortened internodes, forming bunchy heads of small bushy leaves at the tips (Hall 1921, 1926), assuming a multiheaded appearance with multiple damage (Pusha Veni et al. 1973). In heavy infestations, leaves and shoots become compact and crisp. Symptoms in mulberry are known as Tukra disease (Misra 1920b). On mango, infested flowers dry and drop, resulting in fewer, smaller, abnormally shaped fruit that may drop early. *M. hirsutus* is one of those mealybug species to have a toxic saliva which stunts and kills young shoots. Several factors favor *M. hirsutus* infestations: weather, host preferences, perennial-versus-annual host growth, weak or young growth, and apical portions of plants. The rate of development shortened with increasing temperatures, but lengthened with rising relative humidity (Babu and Azam 1987; Mani and Thontadarya 1988).

Several insecticides have been tested against this mealybug. For instance, Beevi et al. (1992) reported that the use of neem oil resulted in reduction of egg hatching. However, most researchers agree that chemical and cultural control provide relief for a short period of time or are ineffective control methods (McComie 1996).

An integrated pest management program has been proposed for the Caribbean region, with classical biological control as the main

component. One of the candidates, the lady beetle [*Cryptolaemus montrouzieri* (Coleoptera: Coccinellidae)] was introduced into Trinidad from India in 1996 (Gautam et al. 1996). Results of the effectiveness of the predator are given by (McComie 1997). For instance, the pink mealybug density at the time of the releases of the lady beetles averaged 19 ovisacs and 14 adults per shoot. A significant decline in the pest population was observed 12 weeks after introduction of the predator (McComie 1997). Another important natural enemy of *M. hirsutus* is *Anagyrus kamali* Moursi (Hymenoptera: Encyrtidae). Moreover, Mani (1989) lists at least 30 species of predators and 16 hymenopterous parasitoids that can be considered as candidates for biological control of *M. hirsutus*.

Heilipus lauri — The large borer-weevil *Heilipus lauri* damages up to 80% of avocado fruits, causing extensive fruit drop. It is distributed in Mexico in the states of Hidalgo, Morelos, Puebla, Veracruz, and Guerrero. The dark-brown (with two incomplete yellow bands on the elytra) adult is 14 mm long and emerges from the fallen fruits (Ebeling 1950). It can fly and regularly mates 2.5 months after emergence. The female deposits her eggs under the epidermis of the developing fruit, making in the latter a "half moon" puncture. The small oval eggs are 1 mm long and change from pale green to cream colored. The female deposits 1 to 2 eggs per fruit and a total of 36 eggs per month. Twelve to 15 days after oviposition, the legless larva bores through the pulp to the seed, where it feeds and spends its larval and pupal existence (Ebeling 1950). The larva has 5 instars that last approximately 54–63 days. Late instar larva measures approximately 2.5 cm (Anonymous 1984). Pupal stage lasts 15 days. Emerging adults feed on the foliage and live up to 4 months. In case of fallen fruits, the larvae sometimes leave the fruit and enter the soil to pupate. The larva initiates a rotting of the pulp, principally near its tunnels, and a partial or total rotting of the seed, eventually resulting in the premature dropping of the fruit. The adult feeds on leaves, buds, sprouts, and in fruit which offer a point of entry, as through a puncture or wound (Ebeling 1950). In Mexico, two generations are observed. The first one occurs from January to August and the second one is observed from July to February (Anonymous 1989).

Conotrachelus aguacatae — The small, shiny, almost black weevil, *Conotrachelus aguacatae*, is regularly not observed in the same orchards where *H. lauri* is prevalent. However, it can cause up to 85% of fruit loss. It is observed in the areas of Queretaro, Michoacan, Jalisco, Puebla, Morelos, and Guanajuato. The adults are 7 mm long, and they can copulate immediately after emergence. The females deposit 1–4 eggs per fruit, but sometimes the number can be as high as 70. Eggs are whitish, and eclose in 7–10 days. The larva develops in the seed and lasts 20–35 days. The number of larvae per fruit could be as high as 3–4. The larvae leave the fruit to pupate in the soil at 5 cm depth. The life cycle from egg to adult is 42–75 days. The first generation starts in January and February and lasts approximately 10 weeks. The second generation starts in April and ends in June or July (Anonymous 1989).

Stenoma catenifer — The seed moth, *Stenoma catenifer*, can perforate 95% of the fruits. It is distributed in Mexico and in some areas of Central and South America. The adult is a small, 1cm, nocturnal moth. Moths will regularly mate 2–3 days after emergence and can live up to 10 days. One day after mating, the female deposits as many as 240 eggs. These eggs are deposited in crevices on the fruit. The egg is 0.6 mm long, oval, and light green. The egg ecloses in 5–6 days, the larva penetrates the fruit and consumes the seed in

20 days. There are 5 instars. Early instars are whitish, while late instars are pink or reddish. Larval stage lasts 16–21 days and pupal stage lasts 11–19 days. The life cycle lasts between 44 and 49 days with 3 complete generations per year. Highest damage is observed between May through August.

***Scirtothrips* spp.** — An undescribed species of Scirtothrips, originally intercepted at the Port of San Diego from a shipment from Oaxaca, Mexico, is now considered the major thrips pest attacking avocados in California. The insect was first noticed in 1996, damaging an avocado orchard in Ventura, Calif. (Hoddle 1998). Avocado thrips females lay eggs singly in an incision made into the soft plant tissue with the ovipositor. Eggs are kidney shaped and whitish-yellow in color. Following egg hatch, developing thrips pass through two actively feeding immature stages called larvae. Adults are straw yellow in color with brown wings (Hoddle 1998). Avocado thrips larvae and adults feed on developing fruit while hidden under the calyx. Fruit is susceptible to damage until it exceeds the size of a half dollar. Feeding scars develop from the calyx, and as feeding damage and feeding continue, scars radiate toward the top of fruit. Fruit scarring can be severe resulting in "alligator skin." Bronzing is observed (Hoddle 1998).

Bactrocera carambolae — The carambola fruit fly, *Bactrocera carambolae* (Drew & Hancock), was found for the first time in the Western hemisphere in Surinam in 1975, although it was properly identified in 1986. This species is endemic to Indonesia, Malaysia, and southern Thailand (Van Sauers-Mueller 1991). In Surinam, the major hosts are carambola, Averrhoa carambola and, the Curaçao apple (*Syzygium samarangese*). Minor hosts include, West Indian Cherry (*Malphigia punificolia*), mango (*Mangifera indica*), sapodilla (*Manilkara achras*), guava (*Psidium guajava*), and Indian jujube (*Ziziphus jujuba*); *Citrus* spp. and cashew are occasional hosts. Export losses to infested countries are calculated to be 25.3 million dollars (Midgarden and Fleurkens 1998). The life cycle of *B. carambolae* is typical of other fruit flies. From egg to mature adult takes about 22 days under good conditions (26°C and 70% RH; Midgarden and Fleurkens 1998). Eggs take 1–2 days to hatch. The larval stage lasts 6–9 days, and pupation 8–9 days. Adults are 3.5–5 mm, blackish yellow with brown tinge, especially on abdomen, head, and legs; ovipositor on female is knife shaped (Midgarden and Fleurkens 1998). Adults become sexually mature in 8–10 days after emergence. The minimum period of time for one generation is approximately 30 days (Midgarden and Fleurkens 1998). The adult female fly feeds for up to a week on protein (e.g., on bacteria growing on fruit and plant surfaces, bird feces, and on sugars, e.g., in honeydew and nectar, spoiled fruit) before laying eggs. Mature adults copulate after groups of males gather and perform a courtship dance in the early evening, just before the sun falls. Females puncture the skin of green or mature fruit and lay eggs in groups of 3–5 just under the skin (Midgarden and Fleurkens 1998). Males and females are strong fliers and will fly long distances if they cannot find a good source of food or a site to lay eggs. Data from *B. dorsalis* have shown that the adults can fly over 50 km from the emergence site (Midgarden and Fleurkens 1998). Adults might live 30–60 days in nature. Females can lay more than 1,000 eggs over their lifetime. Eggs are white, banana shaped, and 1 mm long, shining white, milky when ready to hatch. Larvae have 3 instars inside the fruit where they feed on the pulp and make tunnels in the fruit. Larvae are elongate and pointed at head. Length from 1 mm just after hatching to 7–8 mm just before pupation. The color is white or the same color as the fruit pulp (Midgarden and Fleurkens 1998). At the end of the third instar, the larvae leave the

fruit and burrow 2–7 cm into the soil to pupate. Pupae are dark reddish brown, barrel shaped, and about 4-5 mm long. Since its detection, the fruit fly has spread throughout the coastal areas of Surinam and French Guiana (Sauers-Mueller and Vokaty 1996). An effective control method, called the male annihilation technique, has been developed for members of the *Bactrocera dorsalis* complex. Baits are impregnated with a combination of lure and insecticide. Methyl eugenol, a parapheromone lure, is also used to attract male fruit flies before they become sexually mature. Surveillance methods are accomplished using delta-shaped Jackson traps impregnated with methyl eugenol and an insecticide. Another surveillance method performed in the infested areas consists of collecting fruit and rearing the larvae in screened cages with sand or sawdust.

Current Problems on Taxonomy, Databases, and Basic Biology of Potential Pests

Insect databases for Caribbean islands are few and for the most part not current. Checklists available are limited to a single island. Catalogus Insectarum Jamaicensis by C.C. Godwey was published in three parts in 1926–1928. G.W. Miskimen and R.M. Bond produced a checklist entitled *The Insect Fauna of St. Croix, United States Virgin Islands*. G.N. Wolcott produced *The Insects of Puerto Rico* in 1950–1951. Most recently, in 1998, R.E. Woodruff et al. produced the *Checklist and Bibliography of the Insects of Grenada and the Grenadines*.

Although important, there is rarely support for taxonomic studies that must include concentrated collecting by specialists, mounting, and labeling specimens collected, curating the collections, and having them identified by a dwindling number of taxonomists. The publications produced based on these collections could eventually lead to the development of accurate databases.

Much of the literature on island faunas is based on limited collecting and often not by specialists. As an example, Scudder (1958) listed 17 species of Lygaeidae for the Cayman Islands based on the 1938 Oxford University Expedition, one trip to collect insects in general. Baranowski and Slater (1998) list 50 species including one species new to science. This was based on several collecting trips to the Cayman Islands specifically to collect Lygaeidae. Additionally several specimens that will represent a new genus were collected.

Examples of the importance of concentrated collecting by specialists are (1) the report of Slater and Baranowski (1994) of the presence of the cotton seed bug, *Oxycarenus hyalinipennis*, on North Caicos, Providenciales, and Long Islands. More recently it has been found on the Cayman Islands. This insect is abundant and widespread in Africa and causes severe staining of cotton. *Cymophyes nesocoris* was described by Slater and Baranowski (1997) from the Turks and Caicos Islands. It is mentioned here because the genus *Cymophyes* has not been known from the Western Hemisphere. This is important because it raises the question whether we are dealing with a previously unknown species somewhere in the Eastern Hemisphere or a hitherto uncollected vicariant species, native to the Western Hemisphere. A final example is the report of Henry and Froeschner (1993) of the lygaeid *Dieuches armatipes* being found on Grand Cayman and St. Kitts. Prior to this, members of the genus *Dieuches* were restricted to the Old World. *Dieuches armatipes* is a serious pest of peanuts in Africa where it reduced oil content and caused nuts

to shrivel and become bitter. One specimen of *D. aramtipes* has been collected in Florida (unpub.) and is in the R.M. Baranowski collection. Another example, is the presence of the citrus midge (*Prodiplosis longifila*) in Jamaica, Colombia, and Ecuador. While this species has mostly found infesting flowers of *Citrus aurantifolia* in Florida (Peña et al., 1989), in South America and the Caribbean the "same species" is only collected causing damage to leaves and apical buds of Solanaceae (tomatoes, potatoes, pepper). While in Florida, studies of the life history, sampling, natural enemies, and chemical control of *P. longifila* (Peña et al., 1989; Peña et al., 1990; Peña and Duncan 1992) provided the basis for an effective management program. In the Caribbean and South America, the pest continues to cause severe yield losses to affected crops. A close study of the biology and bionomics of the midge species in the Caribbean and South America would help to clarify the taxonomic status of the species and facilitate its management.

A major effort on training and resource allocation in taxonomy, curating, databases, and basic studies of arthropods in the Caribbean will result in the best tactic to prevent and reduce the effect of potential pests for the Neotropics.

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Table 1. Partial List of Pests Not Currently Present in Tropical Crops Grown in Florida until June, 1999

Host Plant	Pest	Family	Distribution
Avocado	Cryptophlebia leucotreta (Meyr.)	Tortricidae	W. Africa
	Taeniothrips sjostedti (Trybom.)	Thripidae	Africa
	Stenoma catenifer	Oecophoridae	Mexico, Cent. & S.America
	Trialeurodes similis	Aleyrodidae	Mexico
	Liothrips perseae	Phlaeothripidae	Mexico
	Heilipus lauri	Curculionidae	Mexico, Cent. & S.America
	Copturus aguacatae	Curculionidae	Mexico, Cent. & S.America
	Conotrachelus aguacatae	Curculionidae	Mexico, Cent. & S.America
Banana	Hercinothrips bicinctus	Thripidae	E. Africa
	Nacoleia octasema (Meyr.)	Pyralidae	Australasia
	Colaspis hypochlora Lefebre	Chrysomelidae	Cent. & S.America
Coconut	Orycites rhinocerus (Oliver)	Scarabaeidae	India, SE Asia, Pacific Islands
Guava	Anastrepha fraterculus	Tephritidae	Cent. & S.America
Mango	Sternochetus mangiferae (F.)	Curculionidae	Africa, India, Indonesia, Hawaii, Caribbean
	Anastrepha ludens	Tephritidae	Mexico, Central America
	Bactrocera dorsalis	Tephritidae	India, Pakistan, S. Pacific
	Bactrocera passiflorae	Tephritidae	S. Pacific
	Ceratitis cosyra	Tephritidae	W. Africa
	Erosomyia indica	Cecidomyiidae	India, Pakistan, Caribbean
	Erosomyia mangiferae	Cecidomyiidae	India, Pakistan, Caribbean
	Rastrococcus invadens	Pseudococcidae	Africa
Papaya	Rhabdoscelus obscurus Boisd.	Curculionidae	Australasia, Hawaii, Fiji
Passionfruit	Bactrocera passiflorae	Tephritidae	S. Pacific
Carambola	Bactrocera carambolae	Tephritidae	Surinam, SE Asia
Litchi	Aceria litchi	Eriophyidae	Hawaii, Puerto Rico, India, SE Asia
Annonaceas	Maconellicoccus hirsutus (Green)	Pseudococcidae	Guadaloupe, FWI, Near East, India
	Phyllocnistis spp.	Gracillariidae	South America
Tomato	Neoleucinodes elegantalis (Guenee)	Pyralidae	Mexico, Cent. & S.America
Potato	Premnotrypes vorax (Hustache)	Curculionidae	South America

Offshore Research Imperatives Panel

Anthony C. Bellotti, Chair
Carroll Calkins, Raghavan Charudattan, Randy Ploetz
Randall Stoker

Transcript

In the following transcript, panel members are identified by initials. Audience members are identified where possible.

AB — Anthony Bellotti
RS — Randall Stocker
CC — Carroll Calkins
RC — Raghavan Charudattan
RP — Randy Ploetz

AB: As an introduction to the theme of offshore research, I would like each of panel member to introduce themselves and give a very brief opening statement. Then let's get questions from the audience.

RS: My name is Randall Stocker. I'm director of the Center for Aquatic and Invasive Plants at the University of Florida in Gainesville.

We're still gathering information, and frankly, at the moment, we're in a very poor position to make any bold statements about exactly what research needs to be conducted in the Caribbean. We know the sad state of affairs for some basic weedy species in Florida, but we are just now learning how many of those problems we share with the nations around us.

CC: My name is Carroll Calkins. I'm from Yakima, Washington. I used to be in Gainesville, Florida for 21 years, but I'm with USDA-ARS.

I think I'm here because I wrote a chapter in 1986 on research on exotic insects; it was in a book called "Exotic Plant Pests in North American Agriculture." In that chapter, I gave a number of research efforts that we could do before pests enter the United States.

RC: My name is Raghavan Charudattan, but more commonly I go by the name of Charu. I am a member of the Department of Plant Pathology at the University of Florida in Gainesville. I am also a member of Randall Stocker's Aquatic and Invasive Plant Center.

My interests are solely in the area of weed control using plant pathogens as biological agents. I've done some classical biological control work with insects and pathogens and some chemical work and so on.

RP: I'm Randy Ploetz. I'm a research plant pathologist at the Tropical Research and Education Center in Homestead, Florida. I work primarily on subtropical and tropical fruit and vegetable diseases.

AB: The first thing we might look at is priority areas where we think that research is needed. So, any questions in that general area: if we could have those first.

Aud. [Waldemar Klassen]: I'd like to raise a question, and that is: Frequently some of these insects, such as the pink hibiscus mealybug, aren't a big problem in their centers of origin, but suddenly we find them here in our Caribbean neighborhood, and they're hell on wheels. So what is different here; why aren't they a problem where they came from? Why do they manifest themselves here as big problems?

I ask this question because, in the past, I and others have tried to draw up lists of the 100 worst pests. When you look back at the history — the MacGregor report had a long list, and there are other reports — many of the worst pests never showed up on those lists. They don't show up on our radar screen.

So why do we suddenly have these surprises — insects coming from a center of origin into a new area and manifesting themselves in a very severe manner? I don't know if this is true for the plant diseases and weeds as well, but I'd like your opinions.

CC: Many times, when these insects get into a new area, they've left behind their parasites, predators, and their diseases. In the new area, they may be attacking plants that they have never been associated with.

For example, spotted alfalfa aphids came in from the Middle East, and the Middle Eastern alfalfas are quite resistant to them. Alfalfas from Chile, for example, were completely susceptible, and that had nothing to with parasites or predators. It related to the plants they co-evolved with.

But again, the lack natural enemies is a very good reason for these pests exploding.

RS: There have been several attempts to figure out why Florida is so susceptible to weed invasions. (Some say that Florida is a "semi-island," which is somewhat funny when you think about it. It's a long narrow peninsula, and it's similarity to an island is debatable.) Florida is relatively young geologically, influenced dramatically by hydrology, among other factors.

Some work in the Midwest U.S. is finding that it's these very productive ecosystems with high competition levels and lots of nutrients tied up in standing biomass that are actually more susceptible to invasion than the lower diversity, less dynamic situation — at least in the Midwest.

So you go back five years, and you find publications that give one set of reasons for susceptibility to invasion, and then suddenly, you get some Midwest publication that says the former publications were "180 degrees wrong" because of the scale you were looking at, you weren't looking at the richer parts of the proper ecosystems, all these types of discussions ... that tells me that we don't have a clue. We're looking at some interesting things, and frankly, we don't have a clue.

RC: Let me give a specific example. We've been looking at tropical soda apple. There is a scientist in Brazil who is trying to figure out whether there are differences in the soil conditions in southeastern Brazil, where the plant is very common, versus Florida. Definitely, heavy clay soils in Brazil and Paraguay seem to have an effect, and the plant there is not that dominant. Plant competition is certainly a big factor. As Julio Medal showed in his presentation, there's a whole suite of insect agents and a number of plant viruses that attack this plant. Basically, the plant seems to have come here without the natural enemies. Also, poor soil conditions — poor soils, loose soils, high water table — seem to be just ideal for this plant.

RP: Dr. Klassen asked about the situation with plant pathogens. There's a category of plant

diseases called new encounter diseases where you take your host outside its natural range and put it in an area where there might be a pathogen or virus that has not seen that host before. Moko disease on banana is a good example.

Pseudomonas solanacearum evolved in heliconia here in Central America, but when you bring banana over there, you've got a terrible new disease.

African cassava mosaic is another example, and there are a lot of examples of diseases like that. Predicting that those diseases are going to be out there is impossible because you just don't know about the pathogen before it hits the new host.

Aud. [Everton Ambrose]: What criteria can one use, for instance, to prioritize pest lists? It is okay when one thinks about pests in the region, but what about pests that are not in the region, how would you prioritize these for research?

RS: Topic 4 of this conference will be about risk assessment, and I'm sure we'll get into detail then. Nevertheless, the weed side, I can say that it's very discouraging. Australia and New Zealand and many countries have tried to use some kind of prioritization system to assess the risk of potential or future introductions, but the predictions don't match up very well with what is actually found when the plants are introduced.

RP: With plant pathogens, you could look at how a disease or pathogen affects a host in other areas. Citrus greening is a very good example. We know it's a terrible disease, and talk about putting things on the radar screen! Florida already has an effective vector: our citrus producers should be aware of the disease and the potential problem if this pathogen hit our shores. There are other examples where a uniform crop that's been devastated by a pathogen or disease in some area is probably going to be a problem in Florida if it ever arrives.

Aud.: Going back to pink mealybug... Before 1994, no one expected that the pink mealybug would be in the western hemisphere. In a case like this, one probably would not have thought of having this pink mealybug on a list.

CC: One of the ways to prioritize these lists is to look at the host range of these insects. The host range includes economic plants that these insects attack, and you want to look at the value of those plants.

For example, if an insect is coming in, or that has a potential for coming in, that is very devastating on something like wheat, that insect would be a very high priority. You'd also want to look at an insect that has very high biotic potential, which means it has a very good chance of exploding — in one generation maybe having 40 to 400 progeny per female.

Then, an insect may be well controlled where it is, and you know what the control factors are, and you know that those factors aren't in the place where the insect may be introduced. Those insects would be very high priority when they came into the United States.

RC: Here's a slightly different explanation.

Nobody really tries to bring in a known pathogen or insect pest — it just isn't done — and only those plants that are known to be weedy in another location are intentionally kept out. All of the invasive weeds we get, or at least a very large number of invasive weeds we have today were brought in for ornamental purposes or other purposes. So there was a legitimate need and a legitimate way to import some of these plants which later became weeds. Unless there's a prior history somewhere of a particular plant being weedy, we probably would not find a way to exclude

it. That's something that we have to learn to manage.

RS: A researcher at the University of Washington did a matrix analysis of all the features that you would look at in the weediness of plants — number of seeds produced, rapidity of growth, age to first flower production, everything you could imagine. The only factor that showed any real influence was whether the plant had been a problem pest species in some other part of the world.

Aud.: I'm interested in the greening disease and what the strategy might be for doing research on it. It seems to me that, as in all kinds of diseases, the vector is probably going to be infected before there are effective treatments for the disease itself. We already have the vector, and if we know the pest's reproductive strategy, then that implies research on the vector before the disease gets here. Is that something scientists ought to be thinking about?

AB: This is a good point. I think what we have to address is what research could we be doing offshore that would have usefulness when the pest gets here, or that might prevent the pest from getting here at all.

RC: In the case of weeds, we need to identify resources, researchers, and locations where we could perhaps start very early, when the weed is identified as a major problem in Florida. We need locations where studies could be done for finding natural enemies, differences in the weed growth characteristics, and so on. Any kind of biological information we can gather on the weeds — maybe habitat — would certainly help us with plants that we have here. In the case of classical biological control, we need to start very early and identify locations where research can be started.

CC: In terms of insects, I think the database that people have been talking about is extremely important and some of the things that need to go into that database would be life cycle information, number of generations per year, the length of the generations, length of each stage of the generations ... I think the host range of these insects is very important. Also a catalog of the parasites and predators that occur in the area of origin would be a great help in case you wanted to go back and bring those in to control the insect if it ever got in here.

RP: Greening can be controlled in a high intensity system. Thermal therapy works with clonal material if it is infected. You actually have to have fairly high populations of the vector for that disease to take off. So in a worst-case scenario, if the disease were introduced into a Caribbean island — like we have this pink hibiscus mealybug already in the Caribbean — you could use the intervention that has been applied in other places on that island to try to reduce the incidence of the disease and thereby reduce the potential for it reaching Florida. I think one of the big priorities that I see for plant pathogens is to go ahead and continue funding detection technologies. At one time, TSTAR-Caribbean funded Mike Davis for work on *Xanthomonas albilineans*, the sugarcane leaf scald pathogen. That type of work is really important because it not only gives the tools by which we can detect these pathogens, Mike's work also shows us that there are, say, ten different genetically distinct groups of the pathogen but we only have two of them here in Florida. So even though we've got the pathogen here, we can't let our guard down; we still have eight other populations that are out there waiting to affect us. There's a high priority for detection technologies and capabilities, not only for exotic species, but for races or new biotypes of pathogens that are already here.

CC: I think the detection of insects is also very important. Pheromones, identification of pheromones — perhaps synthesis of those pheromones — and other types of trapping methods to detect these insects are all extremely important. The sooner you can detect an invading population, the easier it is to eradicate.

Aud. [Peter Follett]: One comment on what Carroll Calkins was just talking about …

Everything we're suggesting sounds great if you already have baseline information. In the Caribbean basin and in other counties that send produce to Florida, we need to take a step backwards and just start doing pest surveys. Start by looking at new crops, see what's on them, see if there's literature on those particular insects, pathogens, or whatever you're looking for. Start there with a good list of what exists there, what the in-country and regional patterns are — and see how that might overlap with insects you already have in Florida that you might want to keep out.

We're learning this in Hawaii right now where we're starting to grow some crops that haven't been widely grown there. APHIS has put together excellent pest risk assessments for these crops that identify what may be some of their most important pests. But we're learning what's missing from those assessments only after two years of intensive insect surveys and work on the different islands just trying to identify all the things that are coming in.

AB: I think that's a key point. Based on my 25 years in Columbia and 35 years in South America, a follow-up to that is: Who is going to do it? USDA or University of Florida? Does anybody really have an active offshore program in Central America, South America, or any of the Caribbean countries?

Aud. [Richard Brown]: Can APHIS people be sent to Caribbean Islands? Or can other federal government employees be sent to Caribbean islands and do the work? My understanding is that no you can't; somebody has to pay for it. Is that correct or is that incorrect? I haven't really checked into this in the last two or three years, but we were working trying to help Caribbean growers export to the U.S. FAS was particularly interested; they're exporters. I mean, they help U.S. growers export to the Caribbean.

Aud: It depends on how you look at it. There are instances where international services does have programs, and these re paid for by the country. But there are other instances where we have temporarily worked in these countries and helped them in supporting their projects.

Aud. [Gary Greene]: There are operations where APHIS has specific interests in those countries, and we do have people stationed in some of those countries. Of course, you have to set up an arrangement with that country for us to be there.

Aud.: Does that mean it's easier for university staff to do this kind of thing than for federal workers?

Aud.: Yes, yes. I would think so, but I would say that it's relatively easy for APHIS to establish something with the country's agreement

Aud. [Ken Vick]: If there's a valid U.S. interest in doing the research there for finding out how to control pests that might come into the U.S. or finding interdiction methods or finding mitigation methods that protect U.S. agriculture, there's no problem sending federal people to those countries as long as it's not contrary to what the country wants; sometimes our interests are not the same as theirs.

ARS helped Caribbean islands find alternatives to EDB [ethylene dibromide fumigant] back in the 80s. We developed heat treatments in Haiti for mangoes for several of the Caribbean countries. That was done with U.S. funds, not with Caribbean funds.

We have offshore programs; we just need a reason for them. There has to be a U.S. interest.

Aud. [Ted Batkin]: The reasons for looking for some of this offshore research are going to be found in how the SPS agreements shift the responsibilities of risk assessment to exporters. This has raised the anxiety of small countries that export about doing this kind of research. Nevertheless, this gives an opportunity to expand the research community and help these smaller countries.

An important aspect is that potential pests and diseases may be of economic importance or ecological importance. When you start talking about research priorities, whether it's in the Caribbean or the Pacific, there has to be a separation here between pests and disease. Pests of economic importance are going to be a higher priority as far as being able to generate funds for research because of the impacts on trade and commerce. But if you only focus on trade and commerce, you're going to have an ecological disaster that will be just as bad as any economic disaster.

CC: There are a number of ways to finance that type of research. FAO is involved in a lot of research around the world that can be done offshore. FAO is designed primarily to help the country that they're working in. (If they were working on insects that could potentially reach the United States, then these could be added to the database.) IOBC is the International Organization for Biological Control; they're primarily in Europe, but they also work in South America, Africa, and southeast Asia. They're working on biological control organisms all the time (which also can be added to the database). The International Atomic Energy Agency is like FAO; they work on projects that are very important to a certain country. (Any organization we could enlist to work on some of these insects would help the database.) We also have a PL480 Program where government funds that aid some countries can be used only for research in those countries. The money can't be brought back to the United States. Those sorts of things could be used to target insects that we think are of very high priority.

Aud. [Michael Bauscher]: I'd like to make a general comment. Should we be discussing other ways of defeating an invasive pest — some form of resistance work or general resistance work to manipulate plants so that you have knowledge you could use for a particular organism coming in. It seems to me that all the priorities we have now are some way of eradicating or stopping and organism once it's in a country. This is a very expensive process. Where, for example, does plant breeding fit into this?

CC: Plant breeding, in certain cases, involves host plant resistance. The germplasm collections around the world are sources of those plants that have resistance to certain insects, and I think those should be exploited. Many times you wouldn't get into that type of a situation until the insect became established in the United States. But you've got plant introduction germplasm that can be brought into the United Sates so that we can use it in the germplasm collections here in the United States to be screened for resistance. Now something like citrus is a long-term perennial plant; it would be difficult to develop a resistant variety of this plant. But resistant varieties of alfalfa or wheat or corn could be very quickly developed, with our current genetic capabilities — much quicker than we used to with just genetic manipulation.

RP: The same thing is true for plant pathogens. Again, the point to be made with perennial crops is that is a pretty expensive proposition. I know of no examples where somebody is actually trying to address resistance to a disease before it shows up in an area. You already have enough problems without having to worry about something that's offshore.

As far as genetic manipulation such as breeding, I assume you're your talking about biotechnology with insects; it is a little bit more difficult in pathogens. The only success stories are those involving virus-induced diseases which as we saw earlier are actually a minor fraction of diseases. Biotechnology efforts against fungal-induced diseases, which are most important again, really lag far behind. Those are complex situations, so ideally what you would have would be crops that are resistant to a lot of different fungal pathogens. People talk about it and try different strategies, but I know of no success stories right now where we actually have good resistance to one or many plant pathogens on a given crop.

Aud. [Bob McMillan]: The success stories with fungus have been with rust.

RP: You're talking about plant breeding?

Aud. [Bob McMillan]: Yes, and in breeding.

RP: I was talking about biotechnology.

Aud. [Bob McMillan]: And biotechnology, too.

RP: Biotechnology in wheat?

Aud. [Bob McMillan]: No, not on wheat, on legumes and cucurbits.

RS: I'll say on the invasive weed issue … Commercial growers are trying to develop sterile varieties of some of the weedy species. That's kind of laid-back, home-grown breeding programs compared to biotechnology, but at least it is being done.

AB: At CIAT, the International Center for Tropical Agriculture, host plant resistance is one of our major areas of emphasis, and we have developed programs for several crops. For instance, in cassava, we have very good resistance to whiteflies, and we're looking at use of biotechnology right now to identify genes that are involved in that resistance. I agree that host plant resistance is an area that needs to be explored here.

Aud.: What avenues are being used to transmit the information on biotechnology and genetics and so on to the Caribbean Basin so that they can use some of these more resistant varieties or find other methods that might prevent the spread or even the invasion of some of these pests. Is there an avenue that's being used actively for these countries. Or is all this information still locked up in the United States?

RS: It's not locked up. I think that much of the information that's being used now is in U.S. publications. If people are reaching out even a little, a large part of what we're producing is obtainable. A great deal is available on Web sites now.

RC: Right now the biggest avenue for the fruits of our technology is the big agrochemical companies. The have field representatives and marketing mechanisms. They may be giving only one side of the story in some cases, but at least that story is being given to the growers.

RP: A key there is that agrochemical companies have to recoup their investment. This is not cheap stuff to do. Genetically transformed crops is a nice buzzword but it's expensive, and the Novardises and the Monsantos of the world are not going to give

that information or germplasm away until they've recouped their investment. There's an ongoing discussion about using genetically transformed stock in third world and developing countries.

AB: CIAT is heavily involved in biotechnology. We have a unit that's fairly well staffed. We're linked into several universities — Cornell, Clemson, the University of Florida and several others around the world. We're training people from almost all of the countries in Latin America and the Caribbean in different aspects of biotechnology. We also have links to the chemical companies. The biotechnology is moving very much into Latin America in general. Some countries, like Brazil and Argentina, make a tremendous effort in this area and are training a considerable number of people.

Aud. [Ken Vick]: Perhaps the best way to take care of these exotic pests is to keep them out to begin with. If certain weeds aren't known pests until they come in, maybe we need to tighten that up. Especially because it seems that we don't have good measurements to determine how well they're going to do or how weedy they're going to become when they come here. Restricting plant material coming in is always a possibility, but do you have any ideas for weeds or insects or whatever research we might be able to do to help keep pests out — interdiction or what?

RS: We would love to know how things are being introduced. I'm not talking about commercial trade or agriculture, but the pest plant that comes from who-knows-where. Wetland nightshade is an example. It showed up in the middle of the Peace River and Fishing Creek. No one knows where it came from. It also occurs in Cuba and Latin America...

Every time, however, we sit down in a small group with pencil and paper and figure out what we would do, we're up in the tens of millions of dollars without any clear indication that we would actually accomplish much. So for the weed side, pathways are an interesting discussion. We've not been able to get our fingers around how you actually track down currently unknown pathways. That aside, there's so much being introduced now through obvious pathways that I think we better focus on that first before we start getting too fancy.

RP: I have a question for someone in the audience. In Australia, they apparently have back-scattered radiation technology whereby suitcases and luggage go through this device and all living and dead plant material is visualized. It's fairly expensive, but if that technology exists I assume APHIS knows about this. Has there been any discussion of putting that kind of machinery at U.S. ports of entry?. A lot of these pests and disease are coming in on handbags and suitcases, not in commercial shipments.

Aud. [Ted Batkin]: We just went through an in-depth study of the potential technology for this. We looked at tomographic X-ray, which is a high speed X-ray system; it has some definite problems, but there's a new technology called Vivid technology which is a high definition scanning system.

We spend a lot of time in safeguarding talking with the Australians and the New Zealanders about how they do things, and they've got a wonderful situation because they've got about one hundredth of the amount of travel into and out of New Zealand compared to the United States. The problem we're faced with here in Florida as far as passenger screening and luggage screening is that it's incredibly expensive and time sensitive to move passengers through the system. We need technology that is effective in detection and allows passengers and equipment to move rapidly.

We believe that Vivid technology carries that capability, but it's a case now of getting it installed. The first use will be a trial pre-screening in San Juan, Puerto Rico, which will occur this year. If that proves profitable then that technology will be made available for passenger screening in the United States.

I think it has to be kept in mind that the individual passenger coming through with their luggage is a very small part of the total risk analysis process of bringing pests and disease into the United States. Many interests have to be weighed when we start talking to Congress about appropriations: Is the individual passenger a higher risk than other pathways? The problem is the availability of funding to install the technology and make it work in a total risk analysis process.

Aud.: The Vivid unit costs about $300,000 apiece, and then we're looking a putting these into Florida by the year 2001. $300,000 dollars is a pretty good chunk of change when you try to put them into five international airports and none of them would have more than four units. So the costs are very high. The tomographic X-ray , which is a CAT-scanning technology, is still several years down the road before it can be completely put together. Those units will probably cost a million dollars or more.

AB: I'll make one final statement. As a U.S. citizen who has spent most of his career outside the U.S., I think we are being very provincial about this. We're still looking at political borders. Until the University of Florida, for example, has an experiment station somewhere in the Caribbean Basin — if that's where your pest problems are coming from — or until the USDA has a regional program, I don't think were really going to get on top of some of these problems. Let's move the borders a lot further away if that's where our problems are coming from. I think politically this can be done.

Pre-emptive Thrust against the Pink Hibiscus Mealybug: A Model for Meeting Invasive Pest Threats in the Caribbean

Dale Meyerdirk
USDA-APHIS-PPQ-National Biological Control Institute
Riverdale, Maryland

Abstract

The pink hibiscus mealybug, *Maconellicoccus hirsutus* (Green), classical biological control program developed in the Caribbean serves as a model program against invasive pest species that pose an economic threat to the United States. The aggressive classical biological control cooperative effort that was implemented has significantly reduced the population density of this mealybug by 94% in St. Kitts, West Indies, 95% in St. Croix and 90% in St. Thomas, U.S. Virgin Islands. A similar reduction is being observed in Puerto Rico, which has recently become infested. This preemptive thrust into the development of this technology has allowed the United States to "buy time" in developing the technology prior to its entry into the U.S. Mainland, and allows the U.S. to stand ready to transfer this new technology as soon as its needed.

Introduction

A classical biological control program has been developed and implemented by the United States Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS), Plant Protection and Quarantine (PPQ), and international cooperators in the Caribbean Basin against a serious economic insect pest, *Maconellicoccus hirsutus* (Green), the pink hibiscus mealybug (PHM). This pest recently invaded the Western hemisphere in 1994 causing serious economic and environmental damage in Grenada (Pollard 1995). This program was strategically initiated involving USDA in advance of this pest invading the Continental United States. This preemptive thrust into the development of a biological control technology during the early period of this pest's invasion into the Western Hemisphere has allowed the United States and other countries to "buy time" in the development of a biological control program prior to any economic damage in the U.S. and other regions. It also has allowed USDA to apply an acceptable suppression technique to the exploding population densities of this invasive pest on St. Kitts, Nevis and U.S. Territories in the Caribbean, thus reducing the

rate of spread to other local islands that serve as stepping stones into the U.S. and elsewhere. Classical biological control, the technique of importing and releasing exotic natural enemies that become established and self-perpetuating, when applied against a newly established pest, is an environmentally sound pest control technology that is self-sustaining, relatively easy to implement after its development, and is cost efficient. This developed technology for the PHM was readily accepted by and transferred to the Caribbean Basin Countries and serves as a model program for future control technology tactics against other invasive species that enter the Western Hemisphere and pose a threat to the United States and the Caribbean Region.

Geographical Distribution

The geographical distribution of the pink hibiscus mealybug had been restricted to Africa, Asia, Australia and some Pacific Islands including Hawaii, but has recently spread to the immediate Western Hemisphere (Anony. 1997). It was first found in Grenada and Carriacou in 1994 and later spread to three other Caribbean Islands by 1995 including St. Kitts, Nevis and Trinidad . By April of 1998, PHM infested over 20 Caribbean Islands including: St. Thomas, St. John and St. Croix in the U.S. Virgin Islands (V.I.), Vieques, Culebra and the mainland of Puerto Rico, Virgin Gorda and Tortola of the British Virgin Islands, Anguilla, St. Martin, St. Eustatius, St. Lucia, Montserrat, St. Vincent, Tobago, and Guyana in South America. PHM has not been reported invading any new islands since April of 1998, and has not yet been detected in the United States Mainland, Cuba, Dominican Republic, Haiti, Bahamas, Jamaica, Cayman Islands, Central America or Mexico to date (Pollard 1998).

Host Plants

The most common hosts are *Hibiscus* spp., but more than 200 host plants are reported in the literature. These include: *Acacia* spp., *Annona* spp. (soursop), *Asparagus* spp., *Bauhinia* spp., *Capsicum* spp. (peppers), *Citrus* spp., *Coccus* sp., *Cucurbita* spp., *Cucumis sativus* (cucumber), *Erythrina* spp. (bean), *Ficus* spp., *Lactuca sativa* (lettuce), *Manihot esculenta* (cassava), *Medicago sativa* (alfalfa), *Morus* spp. (mulberry), *Prunus* spp. (apricot, plum and peach), *Solanum* spp. (eggplant and potato), *Vitis* spp. (grape), *Zea mays* (corn), etc. (Stibick 1997).

Economic Losses

Cocoa production in Grenada decreased by 30% alone, and total crop losses in Grenada were estimated to be $1.8 million U.S. Dollars (1996-1997) in addition to deleterious effects on the economy, society, and the environment valued between $3.5 to $10 million U.S. Dollars (Francois 1996 and Anony. 1996). Tropical forest trees in Grenada were also significantly damaged or killed by this mealybug. Trinidad estimated losses exceeding $125 million U.S. Dollars per year with continued infestations (Parasram 1996). In India, PHM has been a major pest of grapes causing from 50 to 100% losses and 75% reduction of the sorrel crop, *Hibiscus sabdariffa*. It has also caused major losses to cotton in Egypt. The economic risk to the Continental United States due to the potential invasion of the PHM is estimated to be $750 million per year (Moffitt 1999). Agricultural crops in the mainland of the United States are expected to bear most of the economic risk since PHM hosts include ornamentals; vegetables, citrus, grapes and avocados. Implementation of a biological control program on the U.S. Mainland already developed in the Caribbean will cost

approximately $500,000 per year for three to five years. The expected economic benefits to costs ratio for a single year will exceed 1,500:1. That is, for every dollar spent in the program, $1,500 will be saved.

St. Kitts

The biological control program against the PHM in St. Kitts completed 17 months of operational support. The first parasite releases of *Anagyrus kamali* from China were made August 2, 1996. Within five months of the releases on hibiscus at selected study sites, the mealybug population density of the second, third and adult PHM stages had decreased by an average of 81% in the absence of the predator, *Cryptolaemus*. By the seventeenth month, populations had decreased by a total average of 91.6% with minimal fluctuations. Parasitization in June of 1997 was at a record high averaging 35%. Additional mortality factors include the parasite host feeding, which contributes another 15% to 30% mortality to the mealybug. Hyperparasitization by native hyperparasites was monitored from August through December of 1997 and found to have minimal impact on the mealybug population density. The primary parasites (*A. kamali* and *Gyranusoidea indica*) have two generations for each generation of the mealybug.

The impact of the parasite has resulted in low PHM population densities. The establishment of an exotic parasite complex is believed to be the long term solution for controlling PHM in the Caribbean. All the study sites in St. Kitts, where parasites were released in August of 1996, have had significant recovery from the mealybug infestations, and now have very good leaf flush and normal leaf and flower production, which is an excellent indicator of the health of the plant. Prior to this period, infested hibiscus had minimal to no flowering, curled and stunted leaf and terminal growth, which can result in the death of the plant. As a result of these exotic natural enemy releases, the PHM population density has been significantly reduced throughout St. Kitts, with only localized pockets of newly infested areas left for additional parasite releases or await natural dispersal of these parasites. Telephone calls received and recorded by the St. Kitts Department of Agriculture from concerned home owners regarding damage or losses caused by the PHM were reduced by 90% between April 1996 and April 1997.

U.S. Virgin Islands

PHM was first found in the U.S.V.I. in St. Thomas and St. John in May of 1997 and St. Croix in June of 1997. During a public meeting held in St. Thomas in June of 1997, it was disclosed that PHM damage to hibiscus was observed by residents as early as one year prior to its formal acknowledgment of its identification and presence on the island. Follow-up survey in St. Thomas revealed a wide distribution of PHM across the island, while the infestation in St. Croix occurred at only a few localized areas and was not wide spread.

As of August 1, 1997, USDA-APHIS-PPQ and International Services (IS) began to transfer the biological control technology of the PHM operational program from St. Kitts, West Indies, to the U.S. Territories in the Caribbean. USDA-APHIS, in cooperation with USDA-Agricultural Research Service (ARS), and the U.S.V.I. Department of Agriculture and the University of the Virgin Islands, developed a new insectary and implemented field operations.

The St. Thomas Insectary mass produced the PHM on Japanese pumpkins locally grown by USDA, ARS in St. Croix, and local pumpkins

purchased from local markets. All exotic mass produced natural enemies were released in the U.S.V.I., Puerto Rico, Culebra, Vieques and other Caribbean Islands as requested. Cultures now include *Anagyrus kamali* from China and Hawaii; plus *Gyranusoidea indica* from Egypt, Pakistan and Australia. By February 1999, a total of 6,232 Japanese pumpkins had been harvested in St. Croix. Local pumpkins and acorn squash are now being substituted during shortages of Japanese pumpkins. During June through November of 1998, the St. Thomas Insectary infested an average of 10 pumpkins/day.

A total of 72,410 *A. kamali* and 60,240 *G. indica* were mass produced and released from the St. Thomas Insectary from June 1997 to December 1998. In addition, a total of 45,000 commercially produced *Cryptolaemus montrouzieri* were released in the U.S.V.I. Common parasite releases averaged 100 to 200 individuals per release. A total of 420 release events were made in St. Croix from July 1997 to January 7, 1999; 151 release events in St. Thomas up to January 21, 1999 and 68 releases in St. John up to December 12, 1998.

PHM population densities on hibiscus shrubs at release study sites were reduced by an average of 90% in St. Thomas and over 95% in St. Croix during the period from July 1997 to February 1999. Average parasitization rates varied: St. Thomas 22.9 to 54.5% and St. Croix 2.0 to 36.4% from November 1998 to February 1999. No *C. montrouzieri* were released or recorded present at any of the study sites except at one location in February of 1999, therefore, predators had no significant impact on PHM population densities at these study sites. Successful establishment of these parasites has been observed over 90% of the release sites, based on a special study at 30 release sites in St. Thomas and St. Croix.

Puerto Rico

PHM was first identified in the Puerto Rican Islands of Vieques June 24, 1997. It was later found on Culebra December 3, 1997, and the mainland of Puerto Rico April 28, 1998 in Eastern Fajardo. The PHM later spread to Luquillo on the mainland, which is 1.3 miles from the border of the Caribbean National Forest (El Yunque) by July 30, 1998. It appears that the infestation is beginning to move westward.
A total of 1,250 parasites (*Anagyrus kamali*) were released on six properties on Culebra January 8, 1998, followed by 1,500 parasites (*Gyranusoidea indica*) released on 13 properties in Vieques April 16, 1998. Additional releases have been made on the Mainland of Puerto Rico consisting of 16 properties and a total of 1,200 *A. kamali* and 2,000 *G. indica* between May 22 and August 18, 1998.

Population densities of the PHM in Puerto Rico have been significantly reduced as a result of the exotic natural enemy releases. The decrease in the mealybug's population density at the specific release sites in Puerto Rico averaged 88% from May to November of 1998; 89% in Vieques during this same period; and 95% in Culebra from January to November of 1998 based on an estimate of the mealybug's baseline population density from Vieques. This is similar to the 94% reduction of PHM in St. Kitts, West Indies, observed between August 1996 to April of 1998. The parasitization rates in the Puerto Rican Islands varied from 10.5 to 30.7 % in Puerto Rico, 22.8 to 48.1% in Culebra, and 9.2 to 48.2% in Vieques. Native hyperparasites were recorded attacking these new exotic parasites, but do not appear to interfere with the ability of these exotic parasites to regulate the PHM population density at significantly lower levels.

The St. Thomas, UVI Insectary facility is presently providing all parasites mainly to the U.S. Virgin Islands and Puerto Rico, plus some neighboring Caribbean Islands. A new insectary has just recently been completed in Puerto Rico and is now rearing PHM and presently building up this mealybug culture and initiating parasite cultures. A key limiting factor to parasite production is the availability of Japanese pumpkins. USDA, Agricultural Research Service continues to grow pumpkins in St. Croix despite pestilence and hurricanes, which have caused prolonged fluctuations in production. Local pumpkins (squash) and acorn squash commercially produced are now substituted during shortages of Japanese pumpkins. Japanese pumpkins are now being grown at several location in Puerto Rico for the local insectary.

Future objectives include full production level of the Puerto Rico Insectary reach by September of 1999 and that Japanese pumpkins are successfully grown in Puerto Rico. Parasites will continue to be released at the leading edge of the PHM infestation on the mainland of Puerto Rico with additional releases made in St. Thomas and St. Croix in order to slow the rate of spread and avoid PHM population explosions. PHM surveys must continue in Puerto Rico to determine the movement of the mealybug and a public awareness program must be continued. The present insectary in St. Thomas and the new insectary facility in Puerto Rico will be ready to ship these effective parasites to the States for culturing and field release as soon as the first PHM infestation is identified on the mainland, providing that funding is still available to maintain the U.S. Territory insectaries.

A technology transfer workshop was held in St. Thomas in June of 1998, which provided a Biological Control of Pink Hibiscus Mealybug Project Manual to all participants, who represented numerous States, Caribbean, Central and South American countries, plus Mexico. In addition, training was provided for mealybug and parasite identification, insectary standard operating procedures, along with parasite release and field evaluation procedures. An environmental assessment (EA) was developed for the release of these exotic parasites and had a finding of no significant impact. This EA has been announced in the Federal Register and has led to the approval for field release of these exotic parasites in the U.S. Territories and is now approved for Florida, a high risk State for a PHM infestation in the near future.

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Pre-Clearance Programs and Pest-Free Production Zones in Mexico, Central America, and Caribbean Island Nations

Elena Gomez
USDA-APHIS-IS
Haiti

The following presents 1) a listing of pre-clearance programs, surveillance and interdiction programs, and pest-free production zones by region/country, and 2) the Work Plan for the Sonora Fruit-Fly-Free Zone Program as developed jointly by Mexican and U.S government representatives; the Work Plan is presented in English and Spanish in parallel columns.

Program Listing by Region/Country

Dominican Republic

- Proposed Passenger Pre-Departure Inspection Program.
  Inspecting all U.S.-bound passengers from five international airports to prevent bringing "Classical Swine Fever" to U.S.
- IICA-APHIS Classical Swine Fever Eradication Program.
  6 million not identified.
- Pink Hibiscus Mealy Bug Effort.
  Trained by USDA – will start a survey to be assisted by APHIS.
- Coffee Berry Borer Program.
  Present in Dominican Republic. The country offered training and carries on cultural practices to manage the pest.
- Car "Ferry" Between Dominican Republic and Puerto Rico .
  All luggage and carry-ons are X-rayed. All cargo is inspected with X-ray or manually. All vehicles are inspected by local Ministry of Agriculture personnel. Local customs, immigration, port authority, and other government officials are involved in the procedures.

Suriname, French Guiana, Guyana, Brazil

- Regional Program to eradicate Carambola Fruit Fly (*Bactrocera carambolae*) managed by IICA, funds from IFAD-USDA-APHIS and Gov't of Netherlands. Uses "Male Annihilation Techniques" and has been quite successful. Web site: <www.carambolafly.com>

All CARICOM Countries

- Import/Export Protocol for Pink Hibiscus Mealybug.
- Allows PHM-infested countries to export to non-infested and maintain security.
- Caribbean intra-regional trades in fresh produce.
- Organization of Eastern Caribbean States (OECS).

Bahamas — Nassau & Freeport

- Passenger Pre-Clearance Program.
- Intercepting, safeguarding and destroying any prohibited material.
- Nassau has a Fruit Fly Trapping Program for 5 species of fruit fly (Not Medfly or Mexfly).
- Freeport will soon start a trapping program with the assistance of the Bahamas Ministry of Agriculture.
- Public awareness.

Bermuda

- Passenger Pre-Clearance Program.
  Intercepting, safeguarding, and destroying any prohibited material.
- Plant Quarantine Laboratory(Research and Diagnostic Lab).
  Biological Control Lab.
  Plant Pathology Lab.
  Used for export certification including CITES.
- Citrus Program.
  Pest surveillance.
  Disease recognition.
  Beneficial insects.
  Alternatives to chemical control of extension service.
- No fruit flies of significance.
  Trapping program monitored by APHIS.

Jamaica, Montego Bay & Kingston

- Pre-Clearance Program for Fruits and Vegetables.
- 48 products including cut flowers
  Treatment with M.B.: two treatment facilities for thyme,
  Scotch Bonnet peppers, and yams.
- Training on Pink Hibiscus Mealybug with Jamaican Government.
- Survey conducted: no H.P.M.
- Screwworm Eradication.
  Atomic Energy+USDA and Jamaican Government.
  Dispersing of sterile flies and cultural practices (for the past month).
- Gull Midge (Scotch peppers) – High incidence.
- The Pepper Task Force was established.
  National Strategic Plan:
  Training growers
  Literature
  Site visits.

Caribbean Community and Common Market — Caricom: Member States

- The Caribbean Amblyomma Program (CAP).
- Regional Program co-implemented by the Food and Agriculture Organization & IICA
  Objectives:
  Increase livestock production & reduce imports by 35% by 2005.
  Eradicate the Tropical Boat Tick (TBT).
- TBT
  Increased incidence of skin disease (Dermatophilosis) is the major cause of economic loss in livestock; also transmits Heartwater (cattle, sheep, goats).

Dominica

• Citrus Black Fly Biocontrol Program by parasitoids, spraying by pesticides (Safer Insecticidal Soap and Shell White Oil) until December 1997. (Lack of finances ended the spraying in January 1998).

Grenada

- Fruit-Fly-Free Status.
- 3-year survey of annona and sapodilla for internal feeders.

St. Vincent and the Grenadines

- Fruit-Fly-Free Status.
- Mango seed weevil — present, stopped mango exports.
- Barbados Pre-Clearance System for Root Crops.

Aruba

- Passenger Pre-Clearance Program.
  Conversation with Washington to start the program.

Barbados

- Is doing Pre-Clearance in some Caribbean countries that have Pink Hibiscus Mealybug, issuing producers with ID numbers, and stamping the boxes with the producers IDs along with their inspection stamp (a traceback system).

St. Lucia

- St-Lucian Banana producer pays the Barbados plant quarantine inspector for the identification number and stamps.

Guyana

- Barbados Pre-Clearance System for pineapples and vegetables.

Haiti

- Pre-Clearance Program for mangos.
- Proposed Passenger Pre-Departure Inspection Program.
- Inspect all U.S.-bound passengers from two international airports to prevent bringing of "Classical Swine Fever" to U.S.
- IICA/APHIS "Classical Swine Fever" Eradication Program.
  5 million needed; not identified.
- Pink Hibiscus Mealybug.
- Training in Dominican Republic and later local training.
  Survey was negative.
- Coffee Berry Borer.
  Training in Dominican Republic and later in country.
  Presently detected in the northeast bordering Dominican Republic.
  Cultural practices have prevented the spread of the pest.

Mexico

- Mexican Fruit Fly: Sonora — Baja California Sur.
  Baja California Norte — Pest free-zone.
- Mediterranean Fruit Fly: Southern part of Mexico.
  Trap, sterile fly release.
- Boll Weevil Surveillance Program:
  10, 422 hectares of cotton fields = 400 traps.
  Agricultural Quarantine Inspection.
- Mango Pre-Clearance Program: Hydrothermic Treatment.
  Mango Pilot Program: Government of Mexico to assume responsibilities.
- Avocado Pre-clearance Program: (1997–1998).
  FRESH HASS variety.
  19 Northeastern states.
- Citrus Pre-clearance: Treatment fumigation MB.
- Exotic Animal Disease Commission (1997).
  Prevention of Foot & Mouth Disease and other Foreign Animal disease such as:
    - African Horse Sickness
    - African Swine Fever
    - Avian Influenza
- Hydrilla Eradication Program.
  Release of the sterilized Grass Carp that feeds on the Hydrilla.
- Fresh and frozen pork to U.S.
  Sonora, Sinoloa, Chihuahua, Baja California & Baja California Norte & Yucatan (low risk region for Hog Cholera).
- Bi-National Tuberculosis Monitoring Program.
- Mexican Cattle Imports.
  Texas, California, New Mexico, Arizona, Oklahoma.
  3 phases program still under study.
  Aguascalientes, Baja California, Chihuahua, Coahuila, Duranzo, Nuevo Leon, Sonora, Samoulipas, Veracruz, Yucatan.

WORK PLAN FOR THE SONORA FRUIT-FLY-FREE ZONE PROGRAM

Operated under cooperative agreement between the United States Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS) International Services (IS), and the Secretaria de Agricultura Ganaderia y Desarrollo Rural (SAGAR), and the Comisión Nacional de Sanidad Agropecuaria (CONASAG) represented by the Dirección General de Sanidad Vegetal (DGSV).

This work plan was developed jointly by the United States Department of Agriculture, Animal and Plant Health Inspection Services, International Services (USDA-APHIS-IS) and by the Secretaría de Agricultura, Ganadería y Desarrollo Rural (SAGAR), The Comisión Nacional de Sanidad Agropecuaria (CONASAG), through the Dirección General de Sanidad Vegetal (DGSV) and will be used as a guide for treatment, certification and exportation of apples, grapefruits, oranges, peaches, tangerines, plums, persimmon, apricot and pomegranate to the United States of America. Deviation from these guidelines is not authorized unless previous approval is given by both parties. Any deviation will be documented in writing.

This work plan will be in force until a new one is approved and signed by both parties.

The English version of this document is official.

Concur 1998

DR. ELBA QUINTERO
Regional Director
USDA/APHIS/IS
Region VI, Mexico

PLAN DE TRABAJO PARA EL PROGRAMA DE LA ZONA LIBRE DE MOSCAS DE LA FRUTA DE SONORA

Operado bajo Acuerdo Cooperativo del United States Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS) International Services (IS), y la Secretaría de Agricultura, Ganadería y Desarrollo Rural (SAGAR) y la Comisión Nacional de Sanidad Agropecuaria (CONASAG) representadas por la Dirección General de Sanidad Vegetal (DGSV).

Este plan de trabajo fue desarrollado conjuntamente por el United States Department of Agriculture, Animal and Plant Health Inspection Service, International Services (USDA-APHIS-IS), y por la Secretaría de Agricultura, Ganadería y Desarrollo Rural (SAGAR), y la Comisión Nacional de Sanidad Agropecuaria (CONASAG), a través de la Dirección General de Sanidad Vegetal (DGSV) y será usado como una guía para la exportación de manzanas, toronjas, naranjas, duraznos, mandarinas, ciruelas, persimo, chabacano y granada hacia los Estados Unidos de América. No se autoriza la variación de estos lineamientos, a menos de que sean previamente aprobados por ambas partes. Cualquier desviación de los conceptos aquí mencionados deberá documentarse por escrito.

Este plan de trabajo estará vigente hasta que una nueva versión sea aprobada y firmada por ambas partes.

La versión en inglés de este documento es el oficial.

Acordado el de 1998

DR. LUIS ALBERTO AGUIRRE URIBE
Director General de Sanidad Vegetal
Comisión Nacional de Sanidad Agropecuaria
SAGAR

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B. Programas de tratamiento cuarentenario y directrices para el muestreo de frutas.

WORK PLAN FOR THE SONORA FRUIT-FLY-FREE ZONE PROGRAM

1. Introduction

1. SAGAR has designated the state of Sonora as a fruit-fly-free area, according to procedures established in International Standards.

2. The Administrator of the Animal and Plant Health Inspection Service APHIS has determined that certain definite areas in the State of Sonora, Mexico, meet all the criteria contained in 7 CFR 319.56-2 (e) (4) and 319.56-2 (f) for the importation of certain fruits into the United States, and are free of various species of fruit flies.

3. The procedures outlined in this work plan are designed to assure that the shipments of fruits come from fruit-fly-free zones, according to a biologically sound program to facilitate the movement of fruits for export to the United States.

2. Organizations participating in the Work Plan for the Sonora Fruit-Fly-Free Zone Program

The Work Plan for the Sonora Fruit-Fly-Free Zone Program (hereafter referred as the work plan) will be carried out by the participants listed below:

1. The United States Department of Agriculture, Animal and Plant Health Inspection Service, International Services (USDA-APHIS-IS) referred to in this work plan as "APHIS-IS".

2. The Secretaría de Agricultura, Ganadería y Desarrollo Rural, Comisión Nacional de Sanidad Agropecuaria, Dirección General de Sanidad Vegetal (SAGAR-CONASAG-DGSV), referred in this work plan as"DGSV".

PLAN DE TRABAJO PARA EL PROGRAMA DE LA ZONA LIBRE DE MOSCAS DE LA FRUTA DE SONORA

1. Introducción

1. La SAGAR reconoció como zona libre de moscas de la fruta al estado de Sonora, de acuerdo a procedimientos establecidos en Normas Internacionales.

2. El Administrador del Animal and Plant Health Inspection Service de APHIS ha dispuesto que ciertas áreas definidas en el estado de Sonora, México, cumplen con todos los criterios contenidos en 7 CFR 319.56-2 (e) (4), y 319.56-2 (f) para la importación de ciertas frutas a los Estados Unidos, y están libres de diversas especies de moscas de la fruta.

3. Los procedimientos establecidos en este plan de trabajo estan diseñados para garantizar que los envios de frutos proceden de zonas libres de moscas de la fruta, mediante un programa biológicamente confiable para facilitar la exportación a los Estados Unidos.

2. Organizaciones participantes en el Plan de Trabajo para el Programa de la Zona Libre de moscas de la fruta de Sonora

El Plan de Trabajo Para el Programa de la Zona Libre de Moscas de la Fruta de Sonora (en lo sucesivo llamado "el Plan de trabajo"), será llevado a cabo por los participantes que se enlistan a continuación:

1. El United States Department of Agriculture, Animal and Plant Health Inspection Service, International Services (USDA-APHIS-IS) se denominará en este plan de trabajo como "APHIS-IS".

2. La Secretaría de Agricultura, Ganadería y Desarrollo Rural, Comisión Nacional de Sanidad Agropecuaria, Dirección General de Sanidad Vegetal (SAGAR-CONASAG-DGSV), se denominará en este plan de trabajo como "DGSV".

3. Fruit exporters from Sonora, from here referred as "packers-exporters" through the Comité Estatal de Sanidad Vegetal de Sonora (CESAVESON).

3. Exportadores de fruta de Sonora, en lo sucesivo llamados "exportadores-empacadores" a través del Comité Estatal de Sanidad Vegetal de Sonora (CESAVESON).

3. Participant responsibilities

1. It is the responsibility of APHIS-IS:

1.1 To provide management and supervision of the Program by the Regional Director through the APHIS-IS Area Director as appropriate.

1.2 To provide and maintain a Work Plan for the Program.

1.3 Subject to availability of funds and/or personnel, to provide a sufficient number of designated, qualified local national employees to supervise and execute actions as required in the Work Plan and applicable regulations. These individuals, who will be referred to as inspectors, are USDA employed local nationals under supervision of designated APHIS-IS officers.

1.4 Subject to availability of personnel, and/or to provide additional APHIS-IS and/or PPQ officer to assistant in the Program activities, as dictated by the work load and supervisory needs.

1.5 To verify that the responsibilities of all the participants are properly carried out.

1.6 To provide the necessary manpower to conduct and record sampling of each load of fruit intended for exportation to the United States.

1.7 To reject any lots found to be infested with fruit fly larvae and refuse certification.

1.8 To verify that loads of crates for exportation are strapped and that each crate is stamped with the APHIS-IS official seal. The stamp indicates that the fruit was originated in a definite area.

3. Responsabilidades de los participantes

1. Es responsabilidad de APHIS-IS:

1.1 Dirigir y supervisar el Programa, por parte del Director Regional, a través del Director de Area de APHIS-IS

1.2 Proporcionar y mantener un Plan de Trabajo para el Programa.

1.3 Sujeto a la disponibilidad de fondos y/o personal, proporcionar una cantidad suficiente de empleados nacionales capacitados para supervisar y ejecutar las acciones requeridas en el Plan de Trabajo y en los demás reglamentos aplicables. Estos individuos serán conocidos como "inspectores", son ciudadanos nacionales contratados por USDA bajo la supervisión de los Oficiales designados por APHIS-IS.

1.4 Sujeto a la disponibilidad de personal y/o fondos, proporcionar oficiales adicionales de APHIS-IS y/o de PPQ para ayudar en las actividades del Programa según lo requiera la carga de trabajo y las necesidades de supervisión.

1.5 Verificar que los participantes de este plan de trabajo cumplan debidamente con sus responsabilidades.

1.6 Proporcionar el personal necesario para registrar y llevar a cabo el muestreo de cada carga de fruta para exportación a los Estados Unidos.

1.7 Rechazar cualquier lote que se encuentre infestado con larvas de mosca de la fruta y negarle la certificación.

1.8 Verificar que las cargas de cajas para exportación estén flejadas y que cada caja este estampada con el sello oficial de APHIS-IS. El sello indica que la fruta proviene de un área definida.

1.9 To verify that all the conveyances are clean before loading with certified fruit.

1.9 Verificar que todos los transportes se encuentren limpios antes de que se cargue la fruta certificada.

2. It is the responsibility of DGSV:

2. Es responsabilidad de la DGSV:

2.1 To administer and supervise the work plan, following the procedures established in it.

2.1 Administrar y supervisar el plan de trabajo, siguiendo los procedimientos establecidos en el mismo.

2.2 To approve, select, and certify orchards and packing houses registered to participate in this export program in compliance with the guidelines established in this work plan.

2.2 Certificar los huertos y empacadoras que se hayan registrado para participar en este programa de exportación, en cumplimiento de las directrices de este plan de trabajo

2.3 To supply APHIS-IS with a list of all registered packing houses and orchards at the beginning of the season for inclusion in this work plan. Orchard maps and packing houses plans should be included with this information.

2.3 Proporcionar a APHIS-IS al inicio de cada temporada la relación de los huertos y empacadoras registradas para participar en este plan de trabajo. Mapas con la ubicación de los huertos y planos de las empacadoras deben ser incluídos con esta información.

2.4 To verify that orchards which grow fruit for exportation and packing houses which handle such fruit are registered by DGSV, and to provide APHIS-IS inscription codes assigned to orchards and packers.

2.4 Verificar que los huertos que producen fruta para exportación y las empacadoras que manejen dicha fruta estén registradas ante la DGSV, y proporcionar a APHIS-IS las claves de inscripción asignadas a los huertos y empacadores.

2.5 Immediately inform APHIS-IS of any pest problem encountered during the activities outlined in this work plan.

2.5 Informar inmediatamente a APHIS-IS de cualquier problema de plagas que se encuentre durante las actividades descritas en este plan de trabajo.

2.6 To verify that registered packing houses which knowingly accept fruit registered for exportation from uncertified orchards or fruit that was previously rejected by DGSV automatically lose their certification to export to the United States and to advise APHIS-IS that the service provided by the inspector is suspended.

2.6 Verificar que las empacadoras registradas que acepten fruta de huertos no registrados o que previamente ha sido rechazada por la DGSV, automáticamente pierdan su registro para exportar a los Estados Unidos, lo cual se deberá notificar a APHIS-IS, para que suspenda el servicio proporcionado por el inspector de APHIS-IS.

2.7 To immediately suspend the export certification of those orchards registered in the program according to procedures established in this work plan.

2.7 Suspender inmediatamente la certificación para exportar de los huertos registados en el programa, de acuerdo a lo que se establece en este plan de trabajo.

2.8 To immediately suspend the export certification of packing houses registered in the program identified as a source of infested fruit during the phytosanitary inspection in the United States. The suspension of the packing house will be in effect until an investigation is completed, corrective actions are taken, and APHIS-IS-PPQ and DGSV agree that these particular packing houses should be allowed to export again.

2.8 Suspender inmediatamente la certificación de las empacadoras registradas en el programa cuando se indiquen como origen de la fruta infestada durante la inspección fitosanitaria en los Estados Unidos. La suspensión de la empacadora se mantendrá hasta que sea terminada una investigación, se tomen medidas correctivas, y APHIS-IS-PPQ y DGSV esten de acuerdo en que estas empacadoras en particular deban ser autorizadas para exportar nuevamente.

2.9 To carry out supervision visits in coordination with APHIS-IS to production, packing, inspection, certification and loading areas for fruit shipment to the United States.

2.9 Efectuar visitas de supervisión en coordinación con el APHIS-IS a las áreas de producción, empaque, inspección, certificación y envío de frutos para exportación a los Estados Unidos.

2.10 To make sure that the growers and packing houses are in compliance with requirements relative to origin, transportation to the packing company, selection, packing, inspection, certification, and transportation to the point of entry to the United States. Also DGSV will take corrective actions when procedure errors are discovered.

2.10 Asegurar que los productores y las empacadoras cumplan con los requisitos de origen, transporte a la empacadora, selección, empaque, inspección, certificación y transporte hasta el punto de entrada a los Estados Unidos. La DGSV tomará medidas correctivas cuando se descubra cualquier error de procedimiento.

3. The packers-exporters, through the Comité Estatal de Sanidad Vegetal de Sonora have the following responsibilities:

3. Los exportadores-empacadores, a través del Comité Estatal de Sanidad Vegetal de Sonora tienen las siguientes responsabilidades:

3.1 To comply with all requirements mentioned in the work plan regarding orchards and transportation to the packing house.

3.1 Cumplir con todos los requisitos que se mencionan en el plan de trabajo en relación con los huertos y transporte a la empacadora.

3.2 To furnish DGSV with information regarding to location of orchards that produce fruit for exportation and to get the certification from DGSV to export to the United States.

3.2 Proporcionar a la DGSV información sobre la ubicación de los huertos que producen fruta para exportación a los Estados Unidos y obtener la certificación de la DGSV.

3.4 Send fruit to the United States only by means of packing houses registered and certified by SAGAR.

3.4 Enviar fruta a los Estados Unidos únicamente por medio de una empacadora registrada y certificada por la DGSV.

3.5 To fulfill the requirements of packing, identification, transport and security of fruit shipments for exportation to the United States according to this work plan.

3.5 Cumplir con los requisitos de empaque, identificación, transporte y seguridad de los cargamentos de frutos para exportación a los Estados Unidos, según lo establece este plan de trabajo.

3.6 To register the packing house and get certification from DGSV for exportation to the United States.

3.7 If the packing house is being used to pack fruit for exportation to the United States, this only will accept fruit from orchards certified by DGSV in order to participate in the program for exportation from the Sonora fruit-fly-free zone.

3.8 To participate in the trust fund agreement providing the necessary capital for APHIS-IS personnel, as well as the materials and equipment necessary to carry out the activities and the supervision of the work plan.

3.9 To immediately inform APHIS-IS Regional Director of any problem encountered on route by any conveyance transporting certified fruit and which will prevent it from arriving at the port of entry within a time frame specified by the USDA-APHIS-PPQ certificate.

3.10 Prior to transferring certified fruit from a conveyance involved in an accident or having mechanical problems to another conveyance, the exporter must contact the APHIS-IS Area Director and request the presence of an inspector at the site and that a new APHIS-IS-PPQ certification be issued.

3.11 To ensure that residues of fruit outside the packing houses is removed daily.

4. PPQ regulations policies governing the entry of approved fruits into the United States

Approved fruits are regulated under the Fruits and Vegetables Quarantine, 7 CFR 319.56. APHIS-IS-PPQ policies related to preclearance programs also apply.

As a condition of entry into the United States, approved fruits are required to be from a definite area that is free form all injurious insects that attack fruit as described in 7 CFR 319.56-2 (f).

3.6 Registrar la empacadora y obtener la certificación de la DGSV para exportación a los Estados Unidos.

3.7 Si se está usando la empacadora para empacar fruta de exportación a los Estados Unidos, solo podrá aceptar fruta procedente de huertos certificados por la DGSV a fin de participar en el programa de exportación de la zona libre de Sonora.

3.8 Participar en el acuerdo para el fideicomiso que aporta el capital necesario para pagar el personal de APHIS-IS, así como los materiales y equipo necesario para llevar a cabo las actividades y supervisión del plan de trabajo.

3.9 Informar inmediatamente al Director Regional de APHIS-IS de cualquier problema que se encuentre en su ruta un transporte con fruta certificada, que le impida llegar al puerto de entrada dentro del tiempo especificado en el certificado de USDA-APHIS-PPQ.

3.10 Antes de transferir la fruta certificada de un transporte involucrado en un accidente o que tenga problemas mecánicos a otro transporte, el exportador deberá comunicarse con el Director de Area de APHIS-IS y solicitar la presencia de un inspector en el lugar, que expida un nuevo certificado de APHIS-IS-PPQ.

3.11 Asegurarse que la fruta de rezaga fuera de las empacadoras sea retirada diariamente.

4. Reglamentos de PPQ y las Políticas que rigen la entrada de fruta aprobada a los Estados Unidos

La fruta aprobada queda reglamentada bajo la cuarentena de frutas y hortalizas 7CFR 319.56. También se aplican las políticas de APHIS-IS-PPQ en relación con los programas de verificación en origen.

Como una condición para que la fruta aprobada entre a los Estados Unidos, se requiere que provenga de una área definida como libre de insectos dañinos que atacan a la fruta, de acuerdo a lo establecido por CFR 319.56-2 (f).

Trapping, field certification, and associated safeguarding activities are conducted by the Host Country under policies and conditions of APHIS-IS preclearance program. APHIS-IS policy for preclearance program is that, subject to the existence of a funding agreement to pay all APHIS-IS costs associated with the program including inspections, field treatments, and associated safeguard actions to satisfy entry requirements, actions will be carried out in the country of origin under the supervision of APHIS officers.

El trampeo, la certificación en el campo y las actividades de seguridad asociadas, son efectuadas por el país anfitrión bajo las políticas y las condiciones del programa de verificación en origen de APHIS-IS. La política de APHIS-IS para el programa de verificación en origen señala que está sujeto a la existencia de un convenio de financiamiento para pagar todos los costos de APHIS-IS asociados con el programa, incluyendo inspecciones, tratamientos de campo, en caso de requerirse, y acciones de seguridad asociadas para cumplir con los requisitos de entrada; estas acciones se llevarán a cabo en el país de origen bajo la supervisión de los oficiales de APHIS-IS-PPQ.

Approved fruits will also be subject to inspection and other action at the port of arrival in the U.S. and shall be subject to reinspection at destination at the option of APHIS-IS-PPQ under relations of CFR 319.56-6.

Las frutas aprobadas también estarán sujetas a inspección y otras acciones en el puerto de entrada a Estados Unidos, así como a una reinspección en el punto de destino, a opción de APHIS-IS-PPQ; según los reglamentos de 7 CFR 319.56-6.

5. Criteria for establishing definite areas.

5.1 Within the past 12 months, DGSV has established the absence of infestations of injurious insects known to attack fruits or vegetables in the definite areas based on surveys performed in accordance with requirements approved for the establishment of pest-free areas.

5.2 The country of origin has adopted and is enforcing requirements to prevent the introduction of injurious insects, known to attack fruits and vegetables, into the definite area of the country of origin that are deemed by the APHIS-IS Regional Director to be at least equivalent to those requirements imposed under this chapter to prevent the introduction into the United States and interstate spread of these fruit flies.

5. Criterios para establecer áreas definidas.

5.1 En los últimos 12 meses, la DGSV ha determinado la ausencia de infestación de insectos dañinos en las áreas definidas, que se sabe atacan frutas o verduras, con base en inspecciones llevadas a cabo de conformidad con los requisitos establecidos en normas internacionales para reconocer áreas libres de plagas.

5.2 El país de origen estableció y está aplicando requisitos y procedimientos para impedir la introducción al área definida de dicho país de origen, de insectos dañinos que se sabe atacan frutas y verduras, mismos que el Director Regional de APHIS-IS considera que son equivalentes a los requisitos impuestos bajo este capítulo para prevenir la introducción en Estados Unidos y la diseminación interestatal de moscas de la fruta.

5.3 The DGSV has submitted to the APHIS-IS Regional Director written, detailed procedures for the conduct of surveys and the enforcement of requirements under this paragraph to prevent the introduction of injurious insects. When used to authorize importation under 319.56-2 (e) (3), the criteria must be applied to all injurious insects that attack the fruit or vegetable; when used to authorize importation under 319.56-2 (e) (4), the criteria must be applied to those particular injurious insects from which the area or district is to be considered free.

5.3 La DGSV ha presentado por escrito al Director Regional de APHIS-IS, procedimientos detallados para llevar a cabo inspecciones y poner en vigor los requisitos bajo este párrafo para prevenir la introducción de insectos dañinos. Cuando se utilizan para autorizar importaciones bajo 319.56-2 (e) (3), los criterios deben aplicarse a todos los insectos dañinos que atacan la fruta o la verdura; cuando se utilizan para autorizar importaciones bajo 319.56-2 (e) (4), los criterios deben ser aplicados a los insectos dañinos específicos de los que se considerará libre el área o distrito.

6. Procedures for certifying and maintaining definite areas.

6.1 An active and valid trapping program within the State of Sonora will be carried out according to USDA requirements to detect the presence of the injurious insects as defined in Section 12.3. In addition, surveillance for certain exotic fruit fly species, such as *Bactrocera* spp., and *Ceratitis capitata*, which are not known to exist in Mexico, will also be conducted.

a. Cultivated areas:

- McPhail traps: 5 traps/square mile (1 trap per 50 hectares).
- Jackson traps (trimedlure): 2.5 traps/square mile (1 trap per 100 hectares).
- Jackson traps (cuelure): 1 trap/square mile (1 trap per 250 hectares).
- Jackson traps (methyl eugenol): 1 trap/square mile (1 trap per 250 hectares).

b. Urban areas (including cities, towns and small villages):

- McPhail traps: 15 traps/square mile (3 traps per /50 hectares).

6. Procedimientos para certificar y mantener áreas definidas.

6.1 Se llevará a cabo un programa de trampeo activo y válido dentro del estado de Sonora de acuerdo con los requisitos de USDA para detectar la presencia de los insectos dañinos que se definen en la Sección 12.3. Además, se llevará a cabo la vigilancia de ciertas especies de moscas de la fruta exóticas, tales como *Bactrocera* spp. and *Ceratitis capitata* que no existen en México.

a. Areas cultivadas:

- Trampas McPhail: 5 trampas por milla cuadrada (1 trampa por 50 ha).
- Trampas Jackson (trimedlure): 2.5 trampas por milla cuadrada (1 trampa por 100 ha).
- Trampas Jackson (cuelure): 1 trampa por milla cuadrada (1 trampa por 250 ha).
- Trampas Jackson (metil-eugenol): 1 trampa por milla cuadrada (1 trampa por 250 ha).

b. Areas urbanas (incluyendo ciudades, pueblos y villas):

- Trampas McPhail: 15 trampas por milla cuadrada (3 trampas por 50 hectareas).

• Jackson traps (trimedlure): 5 traps/square mile (1 trap per 50 hectares).

• Jackson traps (cuelure): 1 trap/square mile (1 trap per 250 hectares).

• Jackson traps: (methyl eugenol): 1 trap/square mile (1 trap per 250 hectares).

c. Urban areas in the municipalities of Guaymas and Empalme (including cities, towns and small villages).

• McPhail traps: 25 trap/square mile (1 trap per 10 hectares).

• Jackson traps (trimedlure): 5 traps/square mile (1 trap per 50 hectares).

• Jackson traps (cuelure): 1 trap/square mile (1 trap per 250 hectares).

• Jackson traps: (methyl eugenol): 1 trap/square mile (1 trap per 250 hectares).

Note: For peach and apple orchards, trapping will be conducted from February to July, while citrus orchards will be trapped year-round.

d. Inspection and servicing of traps will be conducted by CESAVESON. McPhail traps will be serviced on a 7-day schedule, and Jackson traps will be serviced every 14 days. APHIS-IS must provide active coordination and supervision of all trapping activities.

• Trampas Jackson (trimedlure): 5 trampas por milla cuadrada (1 trampa por 50 ha).

• Trampas Jackson (cuelure): 1 trampa por milla cuadrada (1 trampa por 250 ha).

• Trampas Jackson (metil-eugenol): 1 trampa por milla cuadrada (1 trampa por 250 ha).

c. Areas urbanas en los muncipios de Guaymas y Empalme (incluyendo ciudades, pueblos y villas).

• Trampas McPhail: 25 trampas por milla cuadrada (1 trampa por 10 hectáreas).

• Trampas Jackson (trimedlure): 5 trampas por milla cuadrada (1 trampa por 50 ha).

• Trampas Jackson (cuelure): 1 trampa por milla cuadrada (1 trampa por 250 ha).

• Trampas Jackson (metil-eugenol): 1 trampa por milla cuadrada (1 trampa por 250 ha).

Nota: Para huertos de duraznos y manzanas, el trampeo se hará de febrero a julio, mientras que para los huertos de cítricos el trampeo se hará durante todo el año.

d. La revisión y el servicio a las trampas estará a cargo del CESAVESON. Se dará servicio a las trampas McPhail conforme a un calendario de 7 días, y a las trampas Jackson cada 14 días. APHIS-IS deberá proporcionar coordinación activa y supervisión de todas las actividades de trampeo.

e. APHIS-IS will utilize dye-marked, sterilized Mexican fruit flies as a quality control measure to insure that traps are properly serviced. Deficiencies in the trapping will be documented and corrective actions will be taken immediately. Any deficiency which is not promptly corrected will result in the suspension of exports from the definite area. In addition, a wing will be cut to the flies used for quality control, by common agreement between DGSV and APHIS-IS.

e. APHIS-IS, en coordinación con DGSV, utilizará moscas mexicanas de la fruta estériles, marcadas con colorante como medida de control de calidad, para asegurar que se esté dando servicio apropiado a las trampas. Las deficiencias en el trampeo serán documentadas y se iniciarán acciones correctivas de inmediato. Cualquier deficiencia que no se corrija inmediatamente resultará en la suspensión de las exportaciones del área definida. Adicionalmente, a las moscas de control de calidad se les cortará un ala, de común acuerdo entre DGSV y APHIS-IS.

6.2 Harvesting, packing, and certifying procedures.

DGSV will enforce the following procedures to maintain the definite areas free from injurious insects.

a. DGSV will map and register all definite areas to include the name of the orchard or grove of origin. Each orchard or grove of origin will be assigned a specific registration number to readily identify the origin of the fruit.

b. The packer-exporters and CESAVESON in coordination with APHIS-IS will issue a guide of mobilization of fruit from the grove to the packing house. This document will be issued locally during fruit harvesting, where the number of the determined area, owner, date of expedition, quantity of fruit, truck number and/or license plate and signature of the person in charge of the grove and personnel from CESAVESON, previous registration of these. The packer-exporters will inform APHIS-IS and CESAVESON in advance of the crop calendar in order to help in field certification.

6.2 Procedimientos de cosecha, empaque y certificación.

La DGSV aplicará los siguientes procedimientos para mantener las áreas definidas como libres de insectos dañinos.

a. La DGSV registrará y marcará en un mapa todas las áreas definidas, incluyendo el nombre de la huerta de origen. A cada huerta de origen se le asignará un número específico de registro para identificar fácilmente el origen de la fruta.

b. Los exportadores-empacadores y el CESAVESON, en coordinación con APHIS-IS expedirán una guía de movilización de la huerta al empauqe. Este documento se expedirá localmente al cosecharse la fruta, donde se especificará el número del área determinada, el propietario, la fecha de expedición, cantidad de fruta, número de camión y/o número de placas y la firma del encargado del huerto y del personal del CESAVESON, previo registro de las mismas. Los exportadores-empacadores informarán a APHIS-IS y al CESAVESON del calendario de cosecha por adelantado para ayudar en la certificación de campo.

c. Harvested fruit must be placed in field boxes that are marked to show orchard registration number. This fruit must be taken from orchard to certificate packing house directly. The fruit must be covered or tarped at all times while being transported. Field trucks will not be authorized to transit definite areas which have been canceled or any other areas considered to be infested, unless the trucks or trailers used to transport the fruit are:

1) Clean and free of debris at the time of loading.
2) Completely closed.
3) Sealed to prevent opening en route.

d. All fruit will be available to APHIS-IS/DGSV inspectors for sampling. The fruit will be cut and examined for fruit fly larvae at a minimum of:

- Apples: 2 fruit per field bin
- Peaches: 2 fruit per field bin
- Citrus: 300 fruits per trailer load (field bin = 20 boxes of 10 kg each)
- Plums: 5 fruit per field bin
- Persimmon, apricot, and pomegranate: 5 fruit per field

e. If any of the fruit is found to contain larvae, all fruits on the premises, whether packed or in bulk, will immediately be held until identification of the specimen can be determined by APHIS-IS. If the specimen is identified as a fruit fly larva of quarantine significance, the orchard where the infested fruit originated will be immediately quarantined out to a radius of 5 miles. Fruit from the quarantined area will not be authorized for movement through adjacent non-quarantined areas unless adequate safeguard measures are taken to allow such movement.

c. La fruta cosechada en las áreas definidas deben ser colocadas en caja de campo, identificadas con el número de registro del huerto. Esta fruta debe ser llevada directamente del huerto a la empacadora aprobada. La fruta debe estar bajo cubierta o protegida con lonas en todo momento mientras es transportada. Los camiones no estarán autorizados para transitar por áreas definidas que hayan sido canceladas ni por ninguna otra área que se considere infestada, a menos que los camiones o remolques utilizados para transportar la fruta estén:

1) Limpios y libres de desechos al momento de cargar.
2) Completamente cerrados.
3) Sellados para evitar que se abran en el camino.

d. Toda la fruta estará a disposición de los inspectores de APHIS-IS/DGSV para tomar muestras. La fruta se cortará y examinará, buscando larvas de mosca de la fruta, en cantidades mínimas de:

- Manzanas: 2 frutas por caja de campo
- Duraznos: 2 frutas por caja de campo
- Cítricos: 300 frutas por carga de camión (caja de campo=20 cajas de 10 kg cada una)
- Ciruelas: 5 frutas por caja de campo
- Persimo, chabacano y granada: 5 frutas por caja de campo

e. Si se encuentra alguna de las frutas con larvas, todas las frutas que se encuentran en el lugar, empacadas o a granel, serán detenidas inmediatamente hasta que el espécimen pueda ser identificado por APHIS-IS en coordinación con DGSV. Si el espécimen es identificado como larva de mosca de la fruta de importancia cuarentenaria, la huerta de donde procedió la fruta infestada será cuarentenada inmediatamente, incluyendo un radio de 5 millas a partir del sitio de captura. No se autorizará el movimiento de fruta de un área cuarentenada a través de áreas no-cuarentenadas adyacentes, a menos que se tomen las medidas adecuadas de protección que permiten dicho movimiento.

Citrus shipments from quarantined areas declared infested will be permitted movement under the following conditions:

1) If the infested fruit is destined to a fly-free area within the state, it must be fumigated with methyl bromide in accordance with the approved treatment schedule under direct supervision of DGSV or APHIS-IS.

2) Export to the United States can only be accomplished if a formal USDA preclearance program is implemented under a separate protocol which would require on-site direct supervision of treatment by APHIS-IS personnel.

f. APHIS-IS will supervise the ink stamping of each box. The stamp will include the following information:

- USDA-APHIS-IS
- Sonora, Mexico-Preclearance Program
- The Packing House Registration Number
- Name of the Definite Area.

1) The USDA ink stamp will be placed half on the label and half on the box.

2) DGSV and the packing house personnel will be responsible for stamping the orchard registration number on each box.

g. Trailers used to transport certified fruit must be completely fruit fly proof and sealed with an APHIS-IS seal with the number recorded on the PPQ form 203 (Master Certificate).

h. Trailers with certified fruit will be accompanied by a master certificate (PPQ form 203) issued by APHIS-IS.

A los embarques de cítricos provenientes de áreas cuarentenadas que se han declarado infestadas se les permitirá el movimiento en las siguientes condiciones:

1) Si la fruta infestada está destinada a un área libre de moscas en el estado deberá ser fumigada con bromuro de metilo de acuerdo con el Programa de Tratamiento aprobado, bajo supervisión directa de DGSV o de APHIS-IS.

2) Se podrá exportar a Estados Unidos únicamente si se sigue un programa formal de preinscripción de USDA bajo protocolo separado, que requeriría la supervisión directa del tratamiento en el lugar por parte del personal de APHIS-IS.

f. APHIS-IS supervisará el sellado con tinta de cada caja. El sello incluirá la siguiente información:

- USDA-APHIS-IS.
- Sonora, México-Programa de verificación en origen.
- Número de registro de la empacadora.
- Nombre del área definida.

1) El sello USDA se colocará, mitad sobre la etiqueta y mitad sobre la caja.

2) La DGSV y el personal de la empacadora serán los responsables de sellar cada caja con el número de registro del huerto.

g. Los camiones que se utilicen para transportar fruta certificada deben ser a prueba de moscas de la fruta, deben estar sellados con un sello de APHIS-IS y el número de éste será registrado en la forma PPQ 203 (Certificado Maestro).

h. Los camiones con fruta certificada llevarán un certificado maestro (forma PPQ 203) expedido por APHIS-IS.

i. After loading, certified fruit will be given a time limit of 48 hours to arrive at the United States port of entry for USDA inspection. Tardiness will immediately cancel the cargo for importation. In cases of accidents or malfunction of the trailers while en route, the fruit can only be transferred to another trailer under APHIS-IS supervision.

i. Se contará con 48 horas para que la carga de fruta transportada en los camiones llegue al puerto de entrada de Estados Unidos para ser inspeccionada por USDA. Cualquier demora cancelará de inmediato la importación de la carga En caso de accidentes o descomposturas de los camiones en el camino, la fruta podrá ser transferida a otro camión solamente bajo supervisión de APHIS-IS.

j. The trailers will proceed from approved packing houses to The United States port of entry by the most direct route.

j. Los camiones se dirigirán de las empacadoras aprobadas al puerto de entrada de Estados Unidos por la ruta más directa.

k. All ducts and openings in trailers used to transport certified fruit will be covered by a 32 mesh screen or closed tightly, and sealed by the APHIS-IS inspector at the point of origin. Trailers must also be clean and free of plant litter and debris.

k. Todos los ductos y aberturas en los camiones utilizados para transportar fruta certificada estarán cubiertos con tela de alambre de malla No. 32, o cerrado y sellado por el inspector de APHIS-IS, en el punto de origen. Además, los camiones deben estar limpios y libres de desechos vegetales.

6.3 Regulatory procedures

6.3 Procedimientos regulatorios

The DGSV will enforce the following procedures to prevent the introduction of the injurious insects of concern into the definite areas as follows:

La DGSV continuará aplicando los siguientes procedimientos para prevenir la introducción de los insectos dañinos motivo de preocupación a las áreas definidas.

a. Quarantine road-stations will be in operation 24 hours of the day at Estación Don, Agua Prieta, Yécora and Alamos for the purpose of conducting vehicular inspection for fruit fly host materials and regulating the treatment and movement of commercial host commodities.

a. Habrá puntos de verificación interna sobre carreteras en Estación Don, Agua Prieta, Yécora y Alamos, funcionando 24 horas al día para hacer inspección de vehículos, buscando materiales hospederos de mosca de la fruta, regulando el tratamiento y el movimiento comercial de los productos hospederos.

1) A 100% inspection of luggage and handbags on buses will be conducted by SAGAR in coordination with civilian or military authorities at Estación Don. Inspection will also be carried out at Agua Prieta, Yécora and Alamos by SAGAR.

1) La SAGAR en coordinación con autoridades civiles o militares en Estación Don, llevarán a cabo la inspección del 100% del equipaje y bolsas de mano en los autobuses. SAGAR también hará inspecciones en Agua Prieta, Yécora y Alamos.

2) All regulated commodities must be treated according to established treatment quarantine programs.

2) Todos los productos regulados deben ser tratados de acuerdo con los programas de tratamiento cuarentenario establecidos.

3) All pertinent data will be correctly entered on the treatment certificate including dosage, initiation and completion time, commodities treated, number of boxes, and weight. All copies of the certificate will be signed on completion of the treatment.

4) Fruits will be sampled prior to treatment. (See appendix B for fruit sampling guidelines.)

5) Following treatment, all boxes will be ink stamped, which will reflect the month, date, and road-station where product was treated.

b. Inspection at airports in Hermosillo, Guaymas, and Ciudad Obregón will be conducted by SAGAR.

c. Trains entering Sonora will be boarded and inspected en route by persons federally commissioned by SAGAR. The trains entering the southern portion of the state will be boarded at Sufragio, Sinaloa or Navojoa, Sonora. Trains entering in the North from Baja California Norte will be inspected at Puerto Peñasco.

d. Vessels will be inspected by SAGAR at maritime ports.

e. Inspection of the markets will be conducted on a regular basis at the central warehouse distribution centers in Ciudad Obregón Hermosillo, Guaymas, Santa Ana, Nogales, Caborca and San Luis Río Colorado.

The purpose of market inspection will be:

1) To check for the presence of fruit fly hosts that are under absolute quarantine (see appendix A), if found, these fruits will be subject to immediate confiscation and disposal. Sellers may be subject to fines and/or punishment specified by Mexican law.

3) Todos los datos pertinentes serán anotados correctamente en el certificado de tratamiento, incluyendo dosificación, hora de iniciación y terminación, producto (s) tratado (s), número de cajas y peso. Todas las copias del certificado serán firmadas al completarse el tratamiento.

4) Se tomarán muestras de la fruta antes del tratamiento. (Ver directrices para muestreo de fruta en el Apéndice B.)

5) Después del tratamiento, a todas las cajas se les pondrá un sello con tinta indicando día y mes, y punto de verificación interna donde fue tratado el producto.

b. La inspección en los aeropuertos de Hermosillo, Guaymas y Ciudad Obregón será llevada a cabo por la SAGAR.

c. Los trenes que entren a Sonora serán abordados e inspeccionados en ruta por personas comisionadas federalmente por SAGAR. Los trenes que entren por la parte Sur del estado serán abordados en Sufragio, Sinaloa. Los trenes que entren por el Norte desde Baja California serán inspeccionados en Puerto Peñasco.

d. Los barcos serán inspeccionados por SAGAR en los puertos marítimos.

e. La inspección de los mercados se llevará a cabo regularmente en los centros de abasto en Ciudad Obregón, Hermosillo, Guaymas, Navojoa, Santa Ana, Nogales, Caborca y San Luis Río Colorado.

El propósito de la inspección en los mercados será:

1) Verificar la ausencia de hospederos de mosca de la fruta de cuarentena absoluta (Ver Apéndice A), de encontrarse estas frutas estarán sujetas a decomiso y destrucción. Los vendedores pueden estar sujetos a multas y/o castigos según la Ley Federal de Sanidad Vegetal de México.

2) To verify that regulated products have been properly treated and that all accompanying documentation corresponds to the goods shipped.

3) To conduct fruit cutting as a means of quality control when it is suspected that live fruit fly larvae might be present.

4) To supervise the unloading of trucks that have been identified at the road-stations for closer examination and have been permitted to proceed to the central market under seal. Any shipment arriving at destination with broken seals will result in a 100% inspection of future shipments at the road-stations.

Detection of live larvae in any imported fruit in the market will be considered a "regulatory incident" and will result in the immediate confiscation and disposal of the infested commodity. A "Detection Alert" will be issued by DGSV and an investigation will be conducted to determine how the product entered the state. An intensive fruit sampling/cutting effort will be carried out in all markets to determine the extent of the problem. The seller may be subject to fines and/or punishment specified by Mexican law.

7. Response to detection of fruit flies.

7.1 Procedures to follow when fruit fly adults are found or captured in the definite areas.

2) Verificar que los productos regulados han sido tratados apropiadamente y que todos tienen la documentación correspondiente.

3) Llevar a cabo la disección de frutas como medio de control de calidad, cuando se sospeche que puede haber larvas vivas de moscas de la fruta.

4) Supervisar la descarga de camiones que hayan sido identificados como sospechosos en los puntos de verificación interna, y que se les haya permitido proseguir al mercado central bajo un sello. Cualquier embarque que llegue a su destino con los sellos rotos ocasionará una inspección del 100% de los embarques futuros en los puntos de verificación interna.

La detección de larvas vivas en cualquier fruta comercializada en los mercados de Sonora, será considerada como un "incidente regulatorio"y resultará la destrucción inmediata del producto infestado. La DGSV expedirá una "Alerta de Detección" y se hará una investigación para determinar como entró el producto al estado, se hará un trabajo intensivo de muestreo y disección de fruta en todos los mercados para determinar el alcance del problema. El proveedor puede estar sujeto a multas y/o castigos según lo especifica la Ley Federal de Sanidad Vegetal.

7. Respuesta a la detección de moscas de la fruta

7.1 Procedimientos que deben seguirse cuando se encuentran o capturan adultos de Mosca de la Fruta en las áreas definidas.

a. In the event of a detection of a single adult male or virgin female fruit fly of any quarantine species as defined in 12.3 or any other exotic fruit fly, the trapping density will be increased to 80 McPhail traps in the square mile area (250 ha) surrounding the initial detection. For exotic fruit flies, trapping densities will be increased to 100 Jackson traps per square mile (250 ha) around the detection site. Any fruit harvested in a definite area within 5 miles (8 km) where the detection occurred will be segregated and held during the following 10-day period. If no subsequent fruit flies of the same species are found during the 10-day period, the fruit is eligible for certification and export.

a. En caso de detección de un solo macho adulto o una hembra vírgen de mosca de la fruta, de cualquier especie cuarentenaria definida en el punto 12.3, o de cualquier otra mosca exótica de la fruta, se aumentará la densidad del trampeo a 80 trampas McPhail en el área de una milla cuadrada (250 ha) alrededor del punto de detección inicial. Para moscas exóticas, las densidades de trampeo aumentarán a 100 trampas Jackson por milla cuadrada (250 ha) alrededor del sitio de detección. Cualquier fruta cosechada en un área determinada en un radio de 5 millas (8 km) donde se haya hecho la detección, será separada y detenida durante los siguientes 10 días, si no se encuentran moscas de la misma especie durante estos 10 días, la fruta será elegible para certificación y exportación.

b. If, within 30 days of the first find, an additional fly of the same species is found within 5 miles of the first capture, the area within 5 miles in all directions of both captures will be considered infested. Unless and until the infestation is subsequently determined to be eradicated, no host fruit of the fruit fly in question will be eligible for export.

b. Sí dentro de los 30 días después de la primera captura se detecta otra mosca de la fruta de la misma especie, dentro de 5 millas (8 km) de donde se hizo la primera captura, el área en todas direcciones a partir de ambas capturas se considerará como infestada. Ninguna fruta hospedera de la mosca de la fruta en cuestión será elegible para exportación del área infestada, hasta que posteriormente se determine que la infestación ha sido erradicada.

c. Urban areas which are infested with one of the fruit fly species listed in 12.3 will be subject to an aerial or ground bait spray 200 meters around the detection area. A minimum of 4 treatments on a 7- to 10-day schedule will be applied. Fruit sampling/stripping and the soil treatments will also be implemented as control measures.

c. Las áreas urbanas infestadas con una de las especies de moscas de la fruta citadas en el punto 12.3, se someterán a un programa de aspersión aérea o terrestre del cebo tóxico, a 200 metros alrededor del área de detección. Se aplicará un mínimo de 4 tratamientos a intervalos de 7 a 10 días. También se instituirá el muestreo/disección de fruta y el tratamiento del suelo como medidas de control.

Growing areas which are infested with one of the fruit fly species listed in 12.3 will be subject to a treatment program (bait spray or sterile release) which will cover the entire orchard plus a buffer area of 300 meters around the orchard.

Las áreas de cultivo infestadas con una de las especies de moscas de la fruta citadas en el punto 12.3., se someterán a un programa de tratamientos (aspersión del cebo tóxico o liberación de moscas estériles, cuando así lo requiera) que cubrirá todo el huerto y un área de protección de 300 metros alrededor del mismo.

The bait spray program will consist of: 1) Aerial bait spray of ULV malathion and protein bait spray, 1:4 ratio at 12 ounces per acre, (877 grams/hectare), or 2) Ground bait spray at the following dosage: 1 liter of Malathion 1000 E, and 4 liters of protein bait diluted in 90 liters of water. The bait treatment will be repeated on a 7- to 10-day schedule and will continue until a minimum of four treatments are applied from the last capture.

El programa de aspersión de cebo tóxico consistirá de: 1). Aspersiones aéreas de cebo tóxico con Malatión ULV y proteína, en una proporción de 1:4, a dosis de 12 onzas por acre, (877 gramos/hectárea) o 2) Aspersiones terrestres de cebo tóxico a razón de un litro de Malation 1000 E, más 4 litros de proteína, diluidos en 90 litros de agua. El tratamiento con cebo tóxico se repetirá siguiendo un programa de 7 a 10 días y continuará hasta haber aplicado un mínimo de 4 tratamientos después de la última captura.

8. Cancellation and reinstatement of groves and packing houses.

8.1 Any fruit offered for exportation to the United Stated which has been introduced from outside an approved definite area or accompanied by an official document including the certificate of origin which has been falsified will result in immediate cancellation of exportation from the grove, packing house and the label involved.

8.2 In the case of fruit coming from outside of an approved definite area and/or the falsification of official documents, a thorough investigation must be conducted to reveal the exact nature of the violation. The APHIS Regional Director will discuss the situation with DGSV and USDA-APHIS-PPQ Staff in Riverdale to decide on the length of the suspension period as well as conditions for reinstatement.

8. Cancelación y reinstalación de huertos y empacadoras.

8.1 Cualquier fruta que se ofrezca para exportación a Estados Unidos, que haya sido introducida de afuera de un área definida aprobada, o que este acompañada por un documento oficial que haya sido falsificado, incluyendo al certificado de origen dará como resultado la cancelación inmediata de la exportación del huerto, empacadora y la etiqueta involucrada.

8.2 En caso de que la fruta provenga de fuera del área determinada aprobada y/o de falsificación en documentos oficiales, deberá hacerse una investigación detallada para determinar la naturaleza exacta de la violación. El Director Regional de APHIS tratará la situación con la DGSV y el personal de APHIS-PPQ en Riverdale, para decidir la duración del período de suspensión así como las condiciones para la reinstalación.

9. Determination of infestation, quarantine within a definite area, and reinstatement of previously infested areas.

9.1 Quarantine Action

a. An infestation will be determined to exist if a larva, a pupa, a mated female, or two or more adults of the same species of economic fruit fly are collected within a 5-mile (8 km) radius within 30 days.

9. Determinación de una infestación, de una cuarentena en una área definida y de la reinstalación de una área previamente infestada.

9.1 Acción Cuarentenaria

a. Se determinará que existe una infestación si se encuentra una larva, una pupa, una hembra grávida o dos o más adultos de moscas de la fruta de importancia económica de la misma especie, en un radio de 5 millas (8 km) durante 30 días consecutivos.

b. The APHIS-IS Area Director will immediately notify the APHIS-IS Regional Office and the DGSV when an infestation exists within a definite area.

c. SAGAR will take immediate action to stop all fruit export from the infested area.

d. The Director General de Sanidad Vegetal will declare a quarantine on all properties within 5 miles (8 km) in any direction of an infested property.

e. The APHIS-IS Regional Office in Mexico City will promptly notify the International Services Director in Riverdale, Maryland by telemail.

f. The APHIS-IS Director will notify Port Operations and other appropriate offices.

9.2 Cancellation of quarantine within a definite area. The infestation will be considered eradicated if no additional fruit fly adults or larvae are found within 3 complete pest generations. Upon approval of APHIS-IS Regional Office, export shipment may be resumed from a formerly infested area provided all other conditions of 7 CFR 319.56-2(f) are satisfied.

10. Suspension of exports

10.1. Exports from a definite area may be suspended by the APHIS-IS Regional Office when it is determined that procedures for maintaining definite areas, including regulatory exports from a definite area, are not adequately followed.

10.2 Definite areas from which exports have been suspended may resume exports when the APHIS-IS Regional Office determines that all procedures are adequately followed.

11. Conditions/Costs:

b. El Director de Area de APHIS-IS notificará inmediatamente a la Oficina Regional de APHIS-IS y a la DGSV cuando exista una infestación en un área definida.

c. La SAGAR tomará acción inmediata para detener la exportación de fruta de un área infestada.

d. El Director General de Sanidad Vegetal establecerá una cuarentena en todas las propiedades en 5 millas (8 km) en cualquier dirección de la propiedad infestada.

e. La Oficina Regional de APHIS-IS en la Ciudad de México, D.F., notificará de inmediato al Director de Servicios Internacionales de Riverdale, Maryland, por correo electrónico.

f. El Director de APHIS-IS notificará a la oficina de Operaciones de Puerto y a otras oficinas apropiadas.

9.2 Cancelación de la cuarentena dentro de un área determinada. Una infestación será considerada erradicada cuando no se encuentran adultos o larvas adicionales de moscas de la fruta durante 3 generaciones de la plaga. Con la aprobación de la Oficina Regional de APHIS-IS, puede reanudarse la exportación de un área anteriormente infestada cuando se hayan cumplido con todas las otras condiciones que establece el CFR 319.56-2(f).

10. Suspensión de exportaciones

10.1 La Oficina Regional de APHIS-IS puede suspender las exportaciones de un área definida cuando se determine que los procedimientos para mantenerla no se siguieron adecuadamente, lo anterior incluye a los procedimientos regulatorios y a los procedimientos para la certificación de exportaciones de un área definida.

10.2 Las áreas definidas que sean suspendidas para exportar, podrán continuar exportando cuando la Oficina Regional de APHIS-IS determine que se han seguido adecuadamente todos los procedimientos.

11. Condiciones/Costos:

11.1 All costs incurred by APHIS-IS including materials, supplies, workhours, overtime, per diem, gasoline costs, and mileage (at established U.S. rates) will be paid through grower trust fund agreements.

11.1 Todos los costos incurridos por APHIS-IS incluyendo materiales, suministros, horas-hombre, tiempo extra, viáticos, costos de gasolina y kilometraje (una tarifa establecida de Estados Unidos) se pagarán a través de un acuerdo de depósito de fondos de los productores.

11.2 A list of approved packing sheds and registration numbers will be provided to APHIS-IS by SAGAR on an annual basis.

11.2 La SAGAR proporcionará anualmente a APHIS-IS una lista de los números de registro de las empacadoras aprobadas.

11.3 The program will be discontinued if any of the conditions established in this work plan are not met.

11.3 El programa será suspendido si cualquiera de las condiciones establecidas en este plan de trabajo deja de cumplirse.

12. Definitions

12.1 **Sonora Fruit-Fly-Free Zone:** Refers to a limited geographical area in the Mexican State of Sonora which is considered to be free of certain injurious insects and maintained as such through trapping, surveys, quarantine road stations, airport, train, and seaport inspections, approved packing facilities, and proper certifications and safeguards to permit biologically sound fruit exports to the United States.

12.2 **Definite Areas:** Refers to those land areas in the Mexican State of Sonora, which are considered free of injurious insects and are listed in the regulations CRF 319.56-2(h), with the understanding that if any area of the listed municipalities fails to meet the criteria as stated in this work plan, those area(s) will immediately be suspended from further consideration under the fruit-fly-free zone concept.

12. Definiciones

12.1 **Zona Libre de mosca de la fruta en Sonora:** se refiere a un área geográfica limitada en el estado de Sonora, México, que se considera libre de determinadas moscas de la fruta de importancia económica, y que es mantenida como tal a través de trampeo, muestreo, puntos de verificación interna en carretera e inspecciones en aeropuertos, trenes y puertos marítimos, instalaciones aprobadas para empaque, certificaciones y dispositivos de seguridad apropiados para permitir las exportaciones biológicamente confiables a Estados Unidos.

12.2 **Areas Definidas:** Se refiere a las áreas de terreno en el estado de Sonora, México que se consideran libres de determinados insectos dañinos y que están listados en los reglamentos (CFR 319.56-2) (h), con el conocimiento de que si alguna área de los municipios listados, en cualquier momento no cumple con las normas que se mencionan en el Plan de Trabajo, esa área o áreas dejaran inmediatamente de ser consideradas bajo el concepto de zona libre de mosca de la fruta.

Municipalities currently considered as definite areas are Altar, Atil, Caborca, Carbó, Empalme, Guaymas (including San Ignacio Río Muerto), Hermosillo, Pitiquito, Plutarco Elías Calles, Puerto Peñasco, San Luis Río Colorado, and San Miguel de Horcasitas. Upon publication of the USDA Final Rule in the Federal Register, the following municipalities will also be considered as definitive areas within the Sonora Fruit-Fly-Free Zone: Bacum, Benito Juárez, Cajeme, Etchojoa, Huatabampo, and Navojoa.

12.3 **Injurious Insects:** Refers to five (5) species of Tephritidae fruit flies (*Anastrepha ludens, A. serpentina, A. obliqua, and A. striata*) which are known to occur in Mexico, and exotic fruit flies *Bactrocera* and *Ceratitis* that threaten the status of the Sonora fruit-fly-free zone.

12.4 **Fruits:** As mentioned in this document, refers to the 9 major fruit crops (apples, grapefruits, oranges, peaches, tangerines, plums, persimmon, apricot, and pomegranate) grown in the Sonora fruit-fly-free zone approved and certified for commercial export to the United States.

12.5 **Growing areas:** Refers to commercial fruit orchards within municipalities where fruits are produced and exported.

12.6 **Urban areas:** Refers to populated areas within municipalities which may or may not include commercial fruit orchards.

12.7 **Approved U.S. port of entry:** Nogales, Arizona.

12.8 **Quarantine:** Refers to a declaration by DGSV to prohibit the movement of all fruit fly host material from an infested area within a definite area.

Los municipios que actualmente se consideran como áreas definidas son: Altar, Atil, Caborca, Carbó, Empalme, Guaymas (incluyendo San Ignacio Río Muerto), Hermosillo, Pitiquito, Plutarco Elías Calles, Puerto Peñasco, San Luis Río Colorado y San Miguel de Horcasitas. Una vez que USDA publique la regla final en el Federal Register, los siguientes municipios también serán considerados como áreas definidas dentro de la zona libre de moscas de la fruta de Sonora: Bacum, Benito Juárez, Cajeme, Etchojoa, Huatabampo y Navojoa.

12.3 **Insectos Dañinos:** Se refiere a cuatro especies de Tefrítidos de moscas de la fruta (*Anastrepha ludens, A. serpentina, A. obliqua y A. striata*) que se sabe existen en México y las moscas exóticas *Bactrocera* y *Ceratitis* que amenazan la condición de zona de Sonora libre de la mosca de la fruta.

12.4 **Frutas:** Como se menciona en este documento se refiere a los 9 cultivos principales de frutas (manzanas, toronjas, naranjas, duraznos, mandarinas, ciruelas, persimon, chabacano y granada) que se cultivan en la zona de Sonora libre de la mosca de la fruta, que están aprobadas y certificadas para exportación comercial a Estados Unidos.

12.5 **Areas de Cultivo:** Se refiere a los huertos comerciales de frutas en los municipios en que se producen y exportan las frutas.

12.6 **Areas Urbanas:** Se refiere a áreas pobladas dentro de los municipios, las que pueden o no incluir huertos comerciales de frutas.

12.7 **Puerto de entrada Aprobado en los Estados Unidos :** Nogales, Arizona.

12.8 **Cuarentena:** Se refiere a una declaratoria de la DGSV que prohibe la movilización de todas las frutas hospederas de moscas de la fruta provenientes de un área infestada, dentro de un área definida.

12.9 **Infested Area:** Refers to all areas within 5 miles of the detection of a larva, a pupa, a mated female of any species of economic fruit fly, or of two or more adult captures of the same species within a five-mile radius within 30 days.

13. Appendix A

Regulation for the movement of fruits from the southern portion of Mexico into the state of Sonora

All fleshy fruit are under absolute quarantine because of their susceptibility to attack by fruit flies (*Anastrepha* spp. and *Ceratitis capitata*).

1. Fruit that can be passed when fumigated:

Common Name	Scientific Name
Plum	*Prunus domestica*
Spanish Plum	*Spondias* spp.
Indian Laurel Fig	*Ficus* spp.
Apricot	*Prunus armeniaca*
Guava	*Psidium guajava* and *P. cattleianum*
Fig	*Ficus carica* and *Ficus* spp.
Sweet Lime	*Citrus limetta*
Sapodilla	*Manilkara zapota* *Achras zapote*
Mamey Sapote	*Pouteria sapota*
Tangerine	*Citrus reticulata*
Mango	*Mangifera indica*
Apple	*Malus sylvestris* and *Malus* spp.
Quince	*Cydonia oblonga*
Sour Orange	*Citrus aurantium aurantium*
Sweet Orange	*Citrus sinesis*
Pear	*Pyrus communis*
Haw, Thornapple	*Crataegus pubescens*
Grapefruit	*Citrus paradisi*

Each shipment must arrive accompanied by a phytosanitary certificate for the national mobilization.

12.9 **Area Infestada:** Se refiere a todas las áreas donde se detecte una larva, una pupa, una hembra grávida de cualquier especie de mosca de la fruta o dos o mas adultos de la misma especie dentro de un radio de 5 millas (8 km) durante 30 días.

13. Apéndice A

Regulación para la movilización de frutas del Sur de México hacia el estado de Sonora

Todo fruto carnoso se encuentra bajo cuarentena absoluta, debido a su susceptibilidad al ataque de moscas de la fruta (*Anastrepha* spp. y *Ceratitis capitata*).

1. **Podrán ingresar bajo el proceso de fumigación:**

Nombre común	Nombre científico
Ciruela	*Prunus domestica*
Ciruela tropical	*Spondias* spp.
Laurel de la India	*Ficus* spp.
Chabacano	*Prunus armeniaca*
Guayaba	*Psidium guajava* y *P. cattleianum*
Higo	*Ficus carica* y *Ficus* spp.
Limón dulce	*Citrus limetta*
Chicozapote	*Manilkara zapota* *Achras zapote*
Zapote mamey	*Pouteria sapota*
Mandarina	*Citrus reticulata*
Mango	*Mangifera indica*
Manzana	*Malus sylvestris* y *Malus* spp.
Membrillo	*Cydonia oblonga*
Naranja agria	*Citrus aurantium aurantium*
Naranja dulce	*Citrus sinensis*
Pera	*Pyrus communis*
Tejocote	*Crataegus pubescens*
Toronja	*Citrus paradisi*

Cada embarque deberá venir acompañado del certificado fitosanitario para la movilización nacional.

2. The following fruits are completely prohibited from entry:

Common Name	Scientific Name
Tropical Almond	*Terminalia catappa*
Sweet & Sour Sops	*Annona* spp.
Breadfruit, Jackfruit	*Artocarpus* spp.
Native varieties of Guava	*Psidium* spp.
Myrtle	*Psidium sartorianum*
"Bonete"	*Leucosperma* sp.
Star apple	*Chrysophyllum cainito*
Icaco, Cocoplum	*Chrysobalanus icaco*
Native variety of Ficus	*Ficus* sp.
Cherimoya	*Annona cherimola*
Native variety of Persea	*Persea* sp.
Cuachilote	*Parmentiera aculeata*
Guaymochil	*Pithecellobium dulce*
Pomegranate	*Punica granatum*
Currant, Gooseberry	*Ribes* sp.
Surinam Cherry	*Eugenia uniflora*

Native fruits in general

Common Name	Scientific Name
Ilama	*Annona diversifolia*
Jimicuil	*Inga* sp. prob. *spuria*
Mombin, Hog-Plum	*Spondias* spp.
Yellow mamey	*Pouteria sapota* *Lucuma* sp.
Cashew Fruit	*Anacardium occidentale*
Juneberry, Serviceberry	*Amelanchier denticulata*
Nance	*Byrsonima crassifolia*
Loquat	*Eriobotrya japonica*
Rose Apple	*Syzygium jambos*
Reyan	*Eugenia* sp.
Saramullo, Custard apples	*Annona* sp.
White Sapote	*Casimiroa edulis*
Drunk Sapote	*Pouteria campechiana*
Persimmon, Dark Sapote	*Diospyros* spp.
St. Domingo Sapote	*Pouteria* spp.

2. Se prohibe la entrada de los siguientes frutos:

Nombre Común	Nombre Científico
Almendro tropical	*Terminalia catappa*
Anona	*Annona* spp.
Arbol del pan	*Artocarpus* spp.
Guayabas nativas	*Psidium* spp.
Arrayán	*Psidium sartorianum*
Bonete	*Leucospermra* sp.
Caimito	*Chrysophyllum cainito*
Icaco	*Chrysobalanus icaco*
Camachín	*Ficus* sp.
Chirimoya	*Annona cherimola*
Chinín	*Persea* sp.
Guajilote	*Parmentiera aculeata*
Guamuchil	*Pithecellobium dulce*
Granada	*Punica granatum*
Grosella	*Ribes* sp.
Cereza de Surinam	*Eugenia uniflora*

Frutas silvestres en general

Nombre Común	Nombre Científico
Ilama	*Annona diversifolia*
Cuajinicuil, Jinicuil	*Inga* sp. prob. *spuria*
Jobo de coche	*Spondias* spp.
Mamey amarillo	*Pouteria sapota* *Lucuma* sp.
Marañón	*Anacardium occidentale*
Guillomo	*Amelanchier denticulata*
Nanche, Nance	*Byrsonima crassifolia*
Níspero	*Eriobotrya japonica*
Pomarrosa	*Syzygium jambos*
Reyan	*Eugenia* sp.
Guanábana	*Annona* sp.
Zapote Blanco	*Casimiroa edulis*
Zapote Borracho	*Pouteria campechiana*
Zapote prieto	*Diospyros* spp.
Zapote de Santo Domingo	*Pouteria* spp.

Treatment schedules for regulated commodities within this appendix

The commodity treatment schedules listed are approved for the fumigation of fruits consumed in the national market. They are not approved for exportation to the United States of America.

1. Mango Fruit:
Methyl Bromide (MB) at NAP-Chamber

40 g/m^3 (2 lbs./1000 ft.^{3}) for 2 hours at 18.3°C (65°F) of above.

2. All Other Approved Fruits

The fruits approved for treatment are listed in Part 1 of this Appendix.

24 g/m^3 (1 lbs./1000 ft.^{3}) for 2 hours at 18.3°C (65°F) or above.

14. Appendix B

Fruit Sampling Guidelines

Number of Boxes	Number of Fruits Sampled
1-10	4 per box
11-20	3 per box
21-50	2 per box
51-100	1 per box
101-400	1 per 2 boxes
401-600	1 per 3 boxes
601-800	1 per 4 boxes
801-1000	1 per 5 boxes
1000	300 fruits

Tolerance limited: Any load exceeding a 0.5% degree of infestation will be confiscated and destroyed.

If fruit fly larvae are found in a single fruit of a sample, another sample of the same number will be drawn and examined for the presence of fruit fly larvae.

Programa de tratamientos para los productos regulados en este apéndice.

El programa de tratamiento para los productos listados, es aprobado para la fumigación de fruta consumida en el mercado nacional. Estos productos no son autorizados para exportarse a los Estados Unidos de América.

1. Mango:
Bromuro de Metilo (BM) 100% puro, en cámaras a presión atmosférica normal.

40 g/m^3 (2 lbs./1000 ft.^{3}) por 2 horas a 18.3°C (65°F) o más.

2. Otros Frutos Autorizados

Los frutos autorizados para fumigarse estan listados en la parte 1 de este Apéndice.

24 g/m^3 (1 lbs./1000 ft.^{3}) por 2 horas a 18.3°C (65°F) o más.

14. Apéndice B

Directrices para el muestreo de la fruta

Número de cajas número de frutas en la muestra	
1-10	4 por caja
11-20	3 por caja
21-50	2 por caja
51-100	1 por caja
101-400	1 por cada 2 cajas
401-600	1 por cada 3 cajas
601-800	1 por cada 4 cajas
801-1000	1 por cada 5 cajas
1000	300 frutas

Límite de tolerancia: Cualquier carga que exceda un grado de infestación de 0.5% será retenida y destruída.

Si se encuentran larvas de mosca de la fruta en una sola fruta de una muestra, se tomará otra muestra del mismo número y se examinará buscando larvas de mosca de la fruta.

Florida's Experience with Citrus Canker: Lessons Learned from History

Timothy S. Schubert
Division of Plant Industries
Gainesville, Florida

Introduction

It is difficult to pack all the major facts learned about citrus canker over the years into this brief presentation, but at least you should know the basic biology of this adversary. Wherever I speak on citrus canker, I acquaint the audience with the symptoms of this disease, so that if they encounter anything like it, they can bring that situation to the attention of the agricultural officials. Canker is a disease that takes a little while to build up to recognizable levels, to the point that the impact of the disease becomes alarming. Even with the constant training given DPI plant inspectors here in Florida, when citrus canker is discovered in an area, it has been active for two or more years before detection and obvious damage. Canker can sneak in and blend with other common citrus diseases at first, but there are some components of the syndrome that are easily recognizable. With some training and confidence, you can probably identify this disease on your own with some certainty. I don't normally recommend this practice. Speaking as a professional plant disease diagnostician, it's always preferable to get the suspect sample to the laboratory or clinic to get an expert opinion. But this is one disease of citrus that can be diagnosed in the field most of the time. The current policy in place in the Citrus Canker Eradication Program (CCEP) in Florida is to undertake a laboratory diagnosis with every sample that arises from a previously canker-free section (each section is a square mile), then perform all subsequent diagnoses in the section in the field by trained specialists, unless there are extenuating circumstances.

[Note: Figures mentioned in this article will be posted at the T-STAR Web site.]

The Geographic Range of Citrus Canker Worldwide and in Florida

The geographical range of bacterial citrus canker [caused by *Xanthomonas axonopodis (campestris)* pv. *citri*] at the present time is just about anywhere in the world where citrus grows in a humid, tropical climate (Fig.1) (IMI 1996).

Florida (Fig. 2) currently has an infestation of major proportions in northern Dade and southern Broward Counties, encompassed by an approximately 500-square-mile quarantine area. Over half of that quarantine area has had some infected citrus in it since the first

detection in the fall of 1995. There is also a 60-square-mile quarantine area over near Tampa Bay in Manatee County. We thought that infestation had been eradicated. The disease was first found in 1986, last detected in 1992, declared eradicated in 1994, but re-emerged a few years later in May 1997. By comparing the genetic fingerprints of the 1986 pathogen to those that are now active there, we can tell that the disease was not completely eradicated. The Manatee County pathogen is genetically different from the organism that is active in Dade and Broward Counties right now. A 41-square-mile quarantine area near Immokalee in Collier County was established in 1998 to contain canker outbreaks in two adjacent commercial groves. There are also a couple of relatively small infestations of the Miami genotype in commercial citrus commencing in early 1999 south and west of Lake Okeechobee encompassed by two approximately 30-square-mile quarantine areas at the present time.

Illustrations of the Bacterial Citrus Canker Syndrome

Figure 3 shows what citrus canker looks like on lemon leaves, both the upper and lower leaf surfaces. The key feature here is that the lesion is raised; it's three-dimensional. You can feel that corky, raised pustule between your fingers on both sides of the lesion. There are other citrus leaf pathogens that can form a raised corky lesion (namely sour orange scab), but generally scab lesions are one-sided, they lack that yellow, chlorotic halo which surrounds the lesion, and they also lack the water-soaked margin that appears regularly on the margins of canker lesion.

Figure 4 shows what the earliest detectable lesion of citrus canker will look like. At this point, at about 7–10 days old, there is nothing more than a clear, raised blister. This would be visible with a hand lens; it is more easily visible if the sample is examined in the clinic under a dissecting microscope. An inspector/scout won't pick this young lesion up in the field very often. If such young lesions are detected, consider yourself very fortunate. Notice the water soaking, the somewhat greasy, wet look around the margin. That is where the bacterial population is at its highest level, and the bacteria are beginning to disassemble plant cells and destroy tissue integrity at this point.

Figure 5 illustrates a lesion about three weeks old. The lesion development has reached the point that the cuticle and epidermis have ruptured, allowing the pustule to dry out and turn brown. It is at this point that the visual inspection for citrus canker is successful in the field. Again, notice how water soaked that lesion can be around the margins. These are critical features of the disease. In a slightly closer view (Fig. 6), notice the raised pustule and water-soaked margin. That is what you should look for in the field.

Most times, it is possible to use the expansion rate of the foliar lesion to help us identify how long citrus canker has been active in an area. This illustration (Fig. 7) shows an unusually large lesion. Most lesions expand about one millimeter a month. This lesion has reached almost a centimeter in diameter. The usual-sized lesion will stop expanding at about half this size (5 mm diameter). If there are lesions present on the stems and fruit (described below), they can provide more clues about how long the disease may have been active in an area. Notice again the bright yellow halo around the leaf lesion. This is a feature that can help the inspector in the field, either in a commercial orchard or in a residential area to key in on that particular symptom.

On occasion, the lesion will take on a very dark, water-soaked, almost blackish-brown border (Fig. 8). This happens on certain sweet orange varieties and lemons in particular. It is not a consistent feature, and it is not something that should alarm you should that be a part of the overall syndrome.

As the lesion gets older, the corky tissues begin to weather away and even fall out, creating a shot-hole effect (Fig 9). But any time the water-soaked border is present along with the three-dimensional aspect, you should think of the likelihood that this is citrus canker.

Keep in mind that citrus canker is a bacterial disease. The organism must be moved passively from one location to another. It cannot propel itself over any significant distance that is important in terms of inoculum dispersal. Wind blown rain in warm weather is the usual way the inoculum gets naturally from one place to another. The spread of the disease is somewhat limited, relying only on the weather to get around. Human activity is how citrus canker spreads over longer distances (Gottwald et al. 1997a).

Leaf lesions are not the only lesions that occur with citrus canker. In fact, all of the above-ground tissues of citrus in their young growing stages are susceptible to the pathogen. In this illustration (Fig. 10), you can see that the same raised, corky pustular lesions have appeared on the young green twigs. Once the disease establishes on the young twig tissues, even though the diseased leaves may fall off and reduce the inoculum level in the tree canopy, these persistent stem lesions produce inoculum right where the new flush is going to emerge. Every new flush is then subjected to a wash of inoculum

Figures 11 and 12 show slightly older stem lesions. These stem lesions will persist for essentially the life of the tree, and can produce inoculum throughout that tree's lifespan. The rough-looking patches on the stem are old citrus canker lesions. As the bark begins to form on these infected stems, no new infections are possible (unless some wounding occurs), but the lesions that formed when that twig was green will persist there indefinitely.

Figure 13 shows what citrus canker in the nursery will look like once it gets full-blown. The disease will defoliate the young trees, plus it will cause numerous stem lesions. This and the next photo are pictures taken in South America. We have never had an Asian strain citrus canker infestation in a registered commercial nursery in Florida since the first eradication program earlier this century. Once canker gains momentum in a young orchard (Fig. 14) with lots of growth flushes (three or four times a year or more in well managed orchards), one can expect to lose much of that new flush every time it appears because of the defoliating effect of the bacterial lesions and the die-back that results from the twig infections.

Citrus fruit can also become infected (Fig. 15). Here's where the impact on the commodity becomes very serious. Illustrated here are very young lesions. With age, they begin to turn brown, and the chlorotic halo emerges (Fig. 16). The halo is absent in most cases on the stems, but on the fruit it becomes quite apparent. Let me point out in Fig. 17 that the lesion is a fairly shallow one. Necrosis is not going to penetrate down into the juice vesicles. It's only in the flavedo and albedo of the rind tissues. The juicing quality of infected fruit is not harmed at all, but for fresh fruit

purposes that blemish is a serious impediment. With heavy fruit infection (Fig. 18), drying and cracking of the rind occurs, and secondary fungal pathogens can get in and ruin the fruit even for juicing purposes. Heavy fruit infections can cause fruit to abscise before ripening.

To summarize, the citrus canker disease is caused by a bacterial pathogen that likes a warm, wet climate, is transmitted in wet, windy weather and by human activity. The pathogen can infect virtually all the above ground tissues: fruit, stems, and mostly the leaves (Fig. 19). Lesions predominate on the leaves. That's where canker first gets established, and from there it begins to cause stem and fruit infections as the inoculum levels increase.

Florida has yet another new pest that has changed our concept of what citrus canker can do in Florida and elsewhere around the world. In l992, shortly after Hurricane Andrew came through, we found that Florida was now infested with the Asian citrus leaf miner (Heppner 1993) (Fig. 20). The fact that the bacterial pathogen can invade wounds and that this new insect pest also likes young flush tissue creates a serious combination. The larvae of the Asian citrus leaf miner (Fig. 21) mines in the epidermis right below the cuticle and forms numerous cracks in that protective layer. The adult moth (Fig. 22) is not something that you would encounter often. It's a tiny creature, but the wounds that the larvae cause in the leaves are a serious matter in terms of citrus canker infection.

Figure 23 illustrates the upper surface of some lemon leaves. You'll notice by looking on the reverse side of the leaves (Fig. 24) that the yellowing is due to simultaneous attack by the leaf miner and citrus canker. Estimates have been made that the inoculum level of citrus canker bacteria that can be produced in the miner-aided infections is probably ten to perhaps one hundred times greater, so the canker infection curve escalates much more quickly with the combination of these two pests (Graham et al. 1996). Normally the citrus canker lesions will appear on both sides of the leaf. You can feel a raised bump on both sides as opposed to the scab lesion, which is usually one-sided, and without that chlorotic halo. In this case with the leaf miner wounding present, there often will not be a raised lesion present on the opposite side. This throws a new twist into the syndrome for field diagnostic purposes.

The leaf miner also invades stems and occasionally fruit, and the canker lesions that can form on the twig are essentially the same as you would expect in the miner-aided infections on the leaves (Fig. 25).

Citrus canker does not infect all varieties or species of citrus uniformly. At the top of the susceptibility list is grapefruit (Fig. 26). Wherever citrus canker is encountered in Florida, whether in a residential or commercial setting, grapefruit is the primary species that picks up the disease and begins the infestation. Key/Mexican lime, if present, is another host of preference. Not all limes are of equal susceptibility. Whereas Key/Mexican lime is extremely susceptible, Persian lime and other lime varieties are lower on the list and much less susceptible. All of the *Poncirus* species that are parents for breeding rootstock are extremely susceptible, and hence, they and their offspring, the citranges and the citrumelos, are extremely susceptible. That

means that root sprouts from these rootstocks pose an additional hazard. In the nursery, of course, trifoliate and trifoliate hybrids would be extremely susceptible. So grapefruit, Key/Mexican lime, and trifoliate citrus are the plants on which we usually detect the disease in the first wave of citrus canker moving through a population.

In the moderately susceptible category is sweet orange. There are ranges of susceptibility within the sweet oranges (Fig. 27). Hamlin, navel, and pineapple are very susceptible in this moderately susceptible category; those varieties will probably have to be taken out of the production scheme in order to get citrus canker down to a manageable level if canker becomes endemic. Valencia is a more resistant sweet orange. Sour orange is very susceptible. Sour orange is grown in nurseries as rootstock, but also appears at root sprouts in orchards, and as dooryard fruit in much of south Florida. Lemons are at the high end in this moderately susceptible category.

It's difficult to put all these citrus species and varieties in an exact susceptibility range. In practice, once the program removes all the grapefruit and Key limes in the first wave of canker infections in an area, the next citrus to come down with the disease are the sweet oranges, tangelos, and lemons. It is the increasingly more resistant citrus that are infected in the second and third waves of canker infections in a residential area.

In the moderately resistant category (Fig. 28) are mandarins, tangerines, and pummelos. In Japan, citrus canker has been endemic for a long time. In order to get export quality fruit, Japanese citrus growers in prescribed areas have resorted to growing mandarins alone, removing all grapefruit from the area, and maintaining extreme surveillance in the area in order to produce the canker-resistant Unshiu orange (a mandarin type) to be exported to the United States (Civerolo 1984).

In the highly resistant category (Fig. 29) are citron, calamondin, and kumquat. None of these are very important commercially.

Lessons Learned from History, 1911–1933

It is a wise person that can learn from another's misfortunes, and I want to give the opportunity to learn from what has happened to the citrus industry here in Florida.

Lesson 1 — The initial introduction of citrus canker into the United States took place unbeknownst to anyone back in about 1910 or 1911 as best we can tell. It apparently came in on some rootstock material from Japan. It became established in Texas, eventually finding its way into Florida from infected Texas rootstock material. Pathologists did not know for certain what the disease was at that time. The scientific community had accepted for a little over a decade that bacterial diseases of plants were possible. At first, the disorder was thought to be scab disease, which is a common fungal disease of citrus. The disease made its way through the channels of commerce throughout the southeastern United States, and nobody realized that this was a new pathogen to the Western Hemisphere until it had reached devastating proportions. Citrus growers in Dade County were the first to realize that eradication was advisable. All the benefits that were just being realized from selected rootstocks budded with

improved scions and all the accompanying free exchange of propagating material came with a very high cost. In 1915, the Florida Legislature passed the Plant Act to legally authorize eradication (Schoulties 1985), and the Federal government passed Quarantine No.19, which prohibited the importation into the United States of any form of citrus propagative material (Dopson 1964). Federal funds were appropriated for the first time for a cooperative state-federal plant disease eradication program.

Lesson 2 — Nurseries for perennial plants pose a particular hazard. Any time a pest or pathogen gets established in a nursery and goes unrecognized, it can get distributed very efficiently throughout the industry in ways that are very difficult to trace and correct retroactively. Therefore, monitoring of nurseries is extremely important. This fact was established conclusively with citrus canker over eighty years ago.

Lesson 3 — It is important to have local scientists who are thoroughly educated about exotic plant diseases and pests. If Florida plant pathologists had been familiar with citrus diseases in Asia, they could have guessed that this exotic disease had a high likelihood for introduction, and probably would have recognized it as a new introduction when it first appeared. A quick response during the early phases would have lessened the impact considerably.

Lesson 4 — In the early citrus canker eradication campaign that ran from 1915 through 1927 in Florida, infected citrus trees were burned in place (Dopson 1964; Loucks 1934). There was not a lot of legal paperwork to be done before action could be taken, such as is necessary in the current program. The first eradication program dealt with infected trees on the spot. If there was a problem, the authorities dealt with that later, *after* removal was completed. That exercise of swift regulatory action, particularly early on, was very beneficial.

Lesson 5 — That eradication campaigns are costly goes without saying. The early campaign (1915–1927) cost over $6 million. Adjusted for inflation, that is the equivalent of over $140 million today. About one fifth of that cost was in lost plant value, and the rest was the labor cost of putting the program together and executing it (Gottwald et al. 1997b).

Lessons Learned from History, 1984–1992

In 1984, Florida plant disease regulators got additional educational opportunities regarding regulatory action on citrus diseases. The lessons were precipitated when a disease appeared in citrus nurseries in Central Florida that was obviously bacterial in nature. At the time, some of the most sophisticated tests available for diagnosis of bacterial diseases indicated that the pathogen was a *Xanthomonas* in the species *campestris*, and presented a fairly convincing serological reaction consistent with the Asian citrus canker pathogen. Although the syndrome lacked the raised pustular aspect of the Asian strain canker lesion for the most part, in virtually all other observable respects it resembled a new strain of canker (Schoulties 1985).

Lesson 1 — The first lesson learned at this point was that new diseases can appear, and such diseases pose an exceptionally tricky

regulatory dilemma. This new pathogen was capable of a disease syndrome very much like Asian citrus canker, identified as the same genus and species as the Asian canker pathogen, apparently quite aggressive where first found, and in a nursery; does it warrant eradication efforts? Florida regulators decided in favor of eradication, and the disease acquired the common name of nursery strain citrus canker.

Lesson 2 — Florida did have the foresight to invest in training opportunities for two key citrus plant pathologists in a year-long program in 1979–80 in Argentina, working with scientists there who knew Asian citrus canker firsthand. In Argentina, the Florida pathologists learned what Asian citrus canker looked like in the field, how to diagnose the disease, and what methods could be used for disease management under South American conditions. The Florida citrus industry certainly was not uninformed about what the disease looked like, or what it could do.

Lesson 3 — During the early stages of the eradication effort against the nursery strain citrus canker, the scientists involved with the program quickly learned that if they were expected to study an organism that is new to science, it would be impossible to discover its biological capabilities and at the same time try to eradicate it. It was possible to move the organism into a quarantine containment facility and study the disease it causes there, but how applicable is what was learned in a quarantine greenhouse to the real world?

Lesson 4 — Any regulatory action must be undergirded with the wisdom of a body of experts from the very beginning. These individuals should be identified and assembled ahead of time so that informed expert opinion will guide the program beforehand to help draw up an emergency action plan, and then be ready to swing into action immediately to help implement that plan at the outset of the emergency.

Lesson 5 — Risk assessment as a formal process was utilized for the first time on a plant disease regulatory program during these troubled times dealing with nursery strain citrus canker in the late 1980s (Schoulties et al. 1987). With some opportunity to study the isolates associated with the syndrome in nurseries around Central Florida, it was learned that the pathogen was actually an array of closely related strains with virulence ranging from mild to aggressive. Many lacked the level of virulence that would cause us to think that it ever could be a problem to the citrus industry, while other isolates actually yielded a water-soaked lesion that progressed more rapidly in a detached grapefruit leaf assay than Asian citrus canker isolates (Graham and Gottwald 1991). All of this was learned at the same time efforts were being made to contain and eradicate the disease. Using risk assessment, the drastic eradication measures were slowed down and lessened by degrees, providing the opportunity to study the pathogen and the disease in remote nurseries where it occurred naturally. A contained outdoor study site was established in North Florida, well removed from the commercial citrus industry, where researchers could artificially inoculate citrus trees in the open. There it was learned that even the most aggressive forms of the pathogen were unable to establish and perpetuate disease in an orchard setting. Furthermore, it took considerable human assistance for the aggressive forms of the disease to get firmly

established in the nursery environment. When an infected tree was taken from the nursery, placed in a simulated commercial orchard environment, away from the overhead irrigation and constant handling, crowded conditions, pruning, etc., the disease essentially disappeared. The taxonomic relationships were refined using genetic comparisons, and the pathogen acquired its own name: *Xanthomonas campestris* pv. *citrumelo* (later reclassified as *X. axonopodis* pv. *citrumelo*), and a new common name was assigned to erase the undeserved "canker" stigma: Citrus bacterial spot (Stall and Civerlolo 1991; Graham and Gottwald 1991).

Lesson 6 — If the expanding knowledge base of the target pathogen is to be of any use, there must be some flexibility built into the regulatory program. It is unwise to take a list of rules and regulations and assume that they will apply for the duration of the program. As long as the changes in the program are based on sound science, it is possible for all persons impacted by regulatory action to be treated fairly, and the goals of the program attained.

Lesson 7 — In spite of being guided by the most appropriate and skilled scientists available, it is likely that legal challenges to regulatory authority will arise, and the program should be prepared for such a development. It is necessary to insure that every diagnosis, every decision at a policy meeting, every interaction with a client has a sound scientific basis, and can be defended in legal proceedings.

Lessons Learned from History, 1986–Present

During the era of the nursery strain citrus canker/citrus bacterial spot regulatory action, the Asian strain citrus canker disease was discovered in the Tampa Bay area for the first time since canker was eliminated from Florida in 1927 and officially declared eradicated in 1933. This newly found Asian citrus canker disease became the target of a separate eradication effort that was active until the last infected tree was detected in 1992, and the disease was declared eradicated after two years of negative inspections in 1994.

Lesson 1 — The program reached the level of no detectable canker by removing all infected citrus plus, and in almost all cases, also removing every exposed citrus within a radius of 125′ from any infected tree. This program should not be considered a total success because the disease reappeared in the same area in 1997. This reinforces the maxim that one must continue surveillance long after citrus canker is apparently eradicated. There is presently no proven way to bait or trap for the citrus canker pathogen using methods similar to those used for early detection of exotic fruit flies. The program depends on visual detection of the disease as inspectors systematically visit commercial and residential plantings of citrus, and as we cross-train insect trappers and every other Division of Plant Industry employee that is out in the field, thus utilizing an augmented inspection network. It is anticipated that this high level of surveillance will pay great dividends. Over the last year, a team of citrus canker experts has trained over one hundred commercial citrus growers, grove managers, caretakers, crew supervisors, packers, haulers,

processors, scouts, buyers, etc., to recognize symptoms of citrus canker so they can serve as an additional detection workforce for the industry, and draw DPI's attention to suspicious symptoms wherever they encounter them.

Lesson 2 — Recent studies conducted in the Dade-Broward canker quarantine zone (where the disease was discovered in residential citrus in 1995) reveal that it is probably not effective to just remove infected trees and exposed trees within 125′. More expansive exposure zones are indicated in this tropical suburban locality where access to trees is slow and difficult, rainfall is greater, windy rainstorms are more common, and human activity to spread inoculum is prevalent. The logistics of an extensive eradication campaign in a residential area are daunting: dispatching field personnel to appropriate areas with reliable transportation every day; convincing residents at every step that the program is justified; getting access to fenced back yards, many with protective pets in them; finding all the citrus present on private property (about half the properties visited have citrus growing on them), removing trees safely and neatly from this crowded environment. Access alone is successful only about 60–80% of the time on any given day.

Lesson 3 — It is important to be prepared for the possibility that the biology of the disease cycle might change at any time. The advent of the Asian citrus leaf miner with the subsequent enhancement of the disease progress curve is a good example. Other opportunities to learn about the disease can come about because of the presence of unfamiliar hosts (the prevalence of sour orange in dooryards in Miami), disease activity in a slightly different climate (tropical Miami vs. subtropical Central Florida), and pathogen behavior in suburban microenvironments rather than in commercial orchards.

Lesson 4 — Furthermore, it is possible to take advantage of unconfined disease development in the field to acquire additional knowledge about epidemiology, even though the existence of this permissive environment is disappointing in the short run from an eradication standpoint. In the last year in northern Dade and southern Broward counties, field research has shown that the 125′ exposure radius is seriously deficient. The data reveal that in order to eliminate 99% of the next generation of infections from an infected tree over a 30-day period, an exposure radius of 1900′ is indicated. It is conceivable that with four strategically placed, infected trees in a section, citrus could be essentially eradicated from that square mile with the implementation of these guidelines. Coupled with any adoption of a larger exposure radius for tree destruction, one must consider how much interference and disruption the general public can tolerate, and at what point will public support for the program erode to the extent that funding is curtailed and/or continual public interference, uncooperativeness, and perhaps even subterfuge cause the program to fail.

Canker eradication program experts remain convinced that with the implementation of tree removal in a larger exposure radius and thorough reinspection of remaining citrus at frequent intervals (from 45-90 day intervals depending on risk), the disease is still eradicable. There are very few diseases, particularly those that are in some way aided by insect activity (not to say that the Asian

citrus leaf miner is a vector, for it is not), that fit into the eradicable category. The scientific community is still in agreement that citrus canker is certainly one plant disease that is possible and advisable to eradicate.

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The Role of CIAT in Meeting the Challenge of New Invasive Pests in the Caribbean Region

Anthony C. Bellotti and Aart v. Schoonhoven
International Center for Tropical Agriculture (CIAT)
Cali, Colombia

Abstract

CIAT, the International Center for Tropical Agriculture, is advantageously positioned geographically, culturally, and scientifically to monitor and carry out innovative research on an array of invasive pests across a wide range of crops and agroecosystems. CIAT has both a germplasm development and a natural resource management base that includes a research portfolio in integrated pest and disease management. In addition, CIAT has formed research and development partnerships with nearly all countries in Central and South America and the Caribbean basin. CIAT's research activities with invasive pests include several whitefly species, including the *Bemisia tabaci* complex, and whitefly-vectored virus diseases. Other threatening pests include rice stripe necrosis virus, the rice mite, *Steneotarsonemus spinki*, the rice thrips, *Stenchaetotrips biformis,* and *Thrips palmi*. CIAT scientists, are also involved in diagnostic surveys in regional cropping systems such as beans, vegetables, cassava, tropical pastures, rice, ornamentals, flowers and oil palm.

Introduction

The International Center of Tropical Agriculture (CIAT: Centro Internacional de Agricultura Tropical), established in 1967 by the Rockefeller and Ford Foundations with support from the Colombian Government, is located near Palmira in the Cauca Valley in southwestern Colombia. CIAT is one of 17 international agricultural research centers (IARCs) sponsored by the Consultative Group on International Agricultural Research (CGIAR). About 20 countries, international agencies, and private foundations support CIAT's research activities, which have both a crop and natural resource focus.

CIAT's mission is: To contribute to the alleviation of hunger and poverty in tropical developing countries by applying science to the generation of technology that will lead to lasting increases in agricultural output while preserving the natural resource base (CIAT 1997).

CIAT staff, which includes 70 scientists from 30 countries, work with national agricultural

research programs (NARS) across Latin America, the Caribbean, Africa, and Asia, to ensure that food production keeps pace with growing demand.

Through germplasm development, CIAT improves four crops that are essential to the world's food supply; CIAT has the global responsibility for research on cassava, common bean, and tropical forages, and for rice research in Latin America and the Caribbean. CIAT's major project portfolio for crop improvement includes:

- Improved beans for Africa and Latin America
- Regional bean network for Africa
- Improved cassava for the developing world in Latin America, Africa, and Asia
- Improved rice for Latin America and the Caribbean
- Multipurpose tropical grasses and legumes

This project portfolio demonstrates some of CIAT's global objectives, responsibilities, and partnerships.

Through natural resources management, CIAT and its national partners develop productive and environmentally sound farming systems for fragile ecosystems threatened by destructive land use. The targeted agroecosystems in tropical Latin America include:

- Hillsides
- Forest margins
- Savannas

CIAT's mandate includes the collection, evaluation, and maintenance of plant genetic diversity. The CIAT gene bank — a treasure for future generations — preserves seeds and living plants of more than 52,000 varieties of beans, cassava, and forage grasses and legumes. These are the building blocks for improved varieties with higher yield potential, genetic resistance to pests and environmental stresses, and the capacity to preserve and restore soil quality. Critical to CIAT's mandate are several research themes that link germplasm development and natural resources management. This project portfolio includes:

- Crop improvement
- Conservation of biological diversity (including biotechnology)
- Agrobiodiversity (including biotechnology)
- Integrated pest and disease management
- Soil quality and production systems
- Land use management
- Geographic Information Services (GIS)

CIAT's project in pest and disease management includes monitoring and research on invasive pests entering Central and South America and the Caribbean basin. CIAT is advantageously positioned geographically, culturally, and scientifically to monitor and carry out innovative research on an array of invasive pests (including arthropods, diseases, and viruses) across a wide range of crops and agroecosystems. In addition to the aforementioned, mandated crops (i.e., beans, cassava, rice, and pastures), CIAT's research portfolio in IPM also includes fruits, vegetables, ornamentals including flowers, oil palms, grains, and legumes.

Networking and Partnerships

Given that CIAT is part of the global CGIAR agricultural research and development system, one of its important strengths is its historic ability to form and participate in networks,

partnerships, and strategic alliances. CIAT's circle of partners includes other IARCs, NARS, universities, non-governmental organizations (NGOs), advanced research institutes, and the private sector.

More than 5,000 scientists have participated in CIAT training programs. Postgraduate opportunities are provided for young scientists in international agricultural research. The CIAT library holds 80,000 books and documents, plus 3,000 journals and bibliographies on rice, cassava, beans, and pastures. CIAT publishes scientific books, conference proceedings, and periodicals for researchers in developing countries.

CIAT has formed more than 20 research partnerships or networks. Examples include:

- Regional collaborative Bean Program for Central America, Mexico, and the Caribbean
- Cassava Biotechnology Network
- Pan American Network for Cassava Improvement
- Caribbean Rice Industry Development Network

From these examples, it can be appreciated that CIAT is active in the Caribbean Region and that we have entered into partnerships with nearly all countries in Central and South America and the Caribbean basin. This gives CIAT an invaluable comparative advantage when we deal with regional problems or projects, being able to link up quickly on regional needs and form strategic networks or alliances to deal with them. In addition, CIAT's strategic position allows it to link the scientific capacities of universities or advanced research institutes to national and regional needs or problems. Given that CIAT is both a global and a regional center, it is in a position to anticipate problems, as well as monitor, evaluate, and research the transcontinental movement of invasive pests.

Sustainable Integrated Management of Whiteflies as Pests and Vectors of Plant Viruses

Whiteflies constitute a major pest problem in agricultural systems in the tropical and subtropical regions of the world. The *Bemisia tabaci* (Gennadius) biotype complex (Brown et al. 1995) (includes *B. argentifolii* Bellows and Perring) (Perring et al. 1993) has invaded Central and South America and the Caribbean Region (Brown 1994; Polston and Anderson 1997). The whitefly is a major pest of many agricultural crops, causing crop losses through direct feeding. *B. tabaci* is also an effective vector of plants viruses (Thresh et al. 1994; Polston and Anderson 1997). Yield losses due to this pest are estimated to total hundreds of millions of dollars (Byrne et al. 1990).
The CGIAR System-wide IPM Programme designated CIAT as the convening center to organize a whitefly IPM Task Force and prepare a proposal on Sustainable Integrated Management of Whiteflies as Pests and Vectors of Plant Viruses in the Tropics. A meeting of the System-wide Whitefly IPM Task Force was held at CIAT in 1996 with representatives from CGIAR research centers (IARCs) NARS and advanced research institutions including universities (Florida and Wisconsin). Participants at this three-day meeting defined the project goal, purpose, outputs, and activities. A concept note and eventually a project proposal were developed.

Project goal: To improve living conditions of rural families through the effective management of whiteflies, resulting in increased crop production and a safer environment.

Project purpose: To reduce crop losses due to whitefly feeding damage and whitefly-transmitted viruses.

There are six major outputs:

- International whitefly network formed
- Whitefly problems and target areas diagnosed and characterized
- Understanding of pest and disease dynamics improved
- Management strategies and tactics developed and tested through participatory methods
- NARS capacity in IPM research, policy formation, and implementation strengthened through information exchange and training
- Project impact assessed

Five IARCs, approximately 30 NARS in Latin America, Africa, and Asia, and eight advanced research institutes, including the universities of Florida, Wisconsin, and Arizona, currently participate in the project. Funding for activities has been by the governments of Denmark (DANIDA), the United States (USAID and USDA), New Zealand (MFAT), and Australia (ACIAR).

Phase I, which is essentially a "diagnostic phase," consists of five subprojects:

- Whiteflies as pests in the tropical highlands of Latin America
- Whiteflies as vectors of viruses in legumes and mixed cropping systems in the tropical lowlands of Central America, Mexico, and the Caribbean
- Whiteflies as vectors of viruses in vegetable and legume mixed cropping systems in eastern Africa
- Whiteflies as vectors of viruses in cassava and sweet potato in Africa
- Whiteflies as vectors of viruses in legumes and mixed cropping systems in Asia.

This diagnostic phase of the project is presently being completed in Latin America and Africa. Results are being tabulated, analyzed and prepared for publication. A World Wide Web home page for the CGIAR Whitefly IPM Project is being developed and will serve to inform the broader scientific community as to the progress and information being generated by the project. It will also link the Whitefly IPM Project to other WWW whitefly home pages.

One of the major results of the diagnostic phase is characterization of the problem areas. Maps are being developed that will illustrate patterns of the whitefly and associated virus disease complex in the different regions or continents. An example of this is the geminivirus complex associated with tomatoes in the Neotropics. Tomatoes are grown throughout the tropical, subtropical, and temperature zones of the Americas. Polston and Anderson (1997) have shown that in the early 1970s, three tomato viruses were reported from the Americas (one each from Brazil, Venezuela, and Mexico). In the 1990s, more than 17 viruses have now been described, at least two of which are reported in the USA. Many of these viruses pose a threat to U.S. agriculture; for example, the tomato yellow leaf curl virus (ToYLCV), recently introduced into the USA. This is a

dynamic situation with new viruses continually emerging (Polston and Anderson 1997).

The CGIAR "Whitefly IPM Project" demonstrates CIAT's capacity to link international and national (NARS) partners with universities and research institutes in a collaborative effort to solve complex regional and global problems, which cannot be effectively addressed by institutions working independently.

Threatening Virus Diseases

In addition to the threat of emerging virus diseases on tomatoes, numerous other crops — including cotton, beans, cucurbits, potato, pepper, melons, and soybeans — have suffered historically from geminiviruses transmitted by whiteflies (Table 1).

BGMV — CIAT's virologists, backed by a fully equipped diagnostic laboratory, have traditionally worked on virus diseases in the region and were instrumental in developing common bean germplasm resistant to bean golden mosaic virus (BGMV), a devastating viral pathogen of beans in tropical Latin America (Morales 1994; Morales and Niessen 1988).

ACMD — Another virus disease that is threatening the region is African cassava mosaic disease (ACMD), caused by several geminiviruses transmitted by *B. tabaci*. ACMD is reported causing crop losses of 18–40% from all African cassava-producing countries (Thresh et al. 1994) . It has not been found in the Neotropics. Until recently, the *B. tabaci* biotypes found in the Americas did not feed on cassava, and it was speculated that the absence of ACMD was related to the inability of its vector (*B. tabaci*) to colonize cassava. Since the early 1990s, however, a new biotype (B) of *B. tabaci*, has been reported feeding on cassava in the Neotropics (Bellotti et al. 1999). Given the presence of this B biotype, ACMD poses a serious threat to cassava production as most traditional varieties are highly susceptible to the disease. CIAT has already introduced ACMD-resistant cassava germplasm from Africa and has crossed these with Neotropical varieties in anticipation of its potential introduction.

Rice virus — During the early 1990s the rice stripe necrosis virus (RSNV) was detected for the first time in Colombia (Morales and Sanint 1998). The origin of the virus appears to be from the Ivory Coast of West Africa, where it was first observed in 1977. It now infests most rice-growing countries in West Africa. RSNV can severely damage recently germinated rice, resulting in estimated production losses of 10–30%. Symptoms include foliage striping, severe plant malformation, and seedling death. Most RSNV outbreaks are associated with periods of water stress (drought) before planting time (CIAT 1998). Molecular characterization of the virus is being carried out at CIAT.

The vector of RSNV is unique in that it is a soil-borne pathogen of the genus *Polymynxa* (possibly *P. graminis*). The virus — which can be disseminated by fungal-contaminated seeds, irrigation water, or agricultural equipment — now infects the principal rice production areas of Colombia. CIAT is monitoring the movement of RSNV, which at present is reported only from Colombia, although it is speculated that it may already be

in other rice-growing countries. Germplasm screening methods have been developed and research to develop resistant varieties has been initiated at CIAT (CIAT 1998).

Threatening Pests

A highly threatening arthropod pest or disease can be characterized by several components. It should have the ability to establish and spread rapidly, cause serious crop losses, and be difficult to control (Thurston 1973). Information on these components is often difficult to find or may not be available. Agroecosystems in the tropical regions of the world, where many pest species originate, are often characterized by numerous crop species and a species-rich complex of pests and natural enemies. A consequence of the lack of knowledge of these complex systems, has often been the inadvertent introduction of insect or disease species into new areas. Adequate prior knowledge of these threatening pests will allow a country or region to prevent or prepare for their introduction.

In recent years, several pests that pose a threat to agricultural production have been introduced into the Caribbean region and other areas of the Neotropics. In some cases, certain pest species, although native to the Neotropics, are confined to a specific area; but if introduced or disseminated into uninfested areas, they could cause crop damage. CIAT scientists are monitoring their damage and movement, and in certain cases, already exploring control or management strategies. A brief description of some of these follows.

Whiteflies — A recent introduction into the region of a whitefly species from Africa is causing concern. The spiraling whitefly, *Aleurodicus dispersus* (Russell), is now reported to be feeding on bananas, cassava, and possibly other crops in Costa Rica and Colombia (Castillo 1996). *A. dispersus* was first reported feeding on cassava in Nigeria, the Ivory Coast, and Benin (Neuenschwander 1994). This pest is presently being monitored to evaluate crop damage as well as host range. A parasitoid of the genus *Encarsia* has been observed parasitizing *A. dispersus* in Colombia; and *E. haitiensis* (Dozier) and *E. guadeloupae* Viggiani are reported parasitizing it in Benin (D'Almeida et al. 1998).

A USAID-funded collaborative project between CIAT and the University of Florida was started in 1998 to determine the complex of indigenous neotropical parasitoids associated with the whitefly complex found on cassava, beans, cotton, and selected horticultural crops. Surveys have been initiated in northern South America (Colombia, Venezuela, and Ecuador) in order to select the best potential natural enemies for continued research and to compare the efficiency of indigenous species to that of exotic whitefly parasitoids being recommended for introduction into the region.

Preliminary results show that there is a species-rich parasitoid complex associated with the numerous whitefly species collected from the aforementioned crops (Tables 2 and 3). Several of the parasitoid species are unrecorded and in the process of being identified (Evans and Castillo 1998). For this reason, parasitoid species in tables 2 and 3 are identified only to genera, pending taxonomic

confirmation from University of Florida taxonomists.

Rice mite — The phytophagous mite *Steneotarsonemus spinki* Smiley (Tarsonemidae) is reported as an important pest of rice in several Asian countries, including Taiwan, Philippines, Japan, and China (Chow et al. 1980). The species was first collected in 1960, on *Sogata orizicola* Muir, a plant hopper pest of rice, in Baton Rouge, Louisiana, USA (Smiley 1967) lending to some question as to the actual origin of the species. After this initial report, only minimal information on this pest has appeared in the literature, and it appears that it did not cause severe damage to the rice crop.

However, in 1997 it was reported causing significant damage to rice in Cuba (Ramos and Rodríguez 1998), and subsequent reports from the Dominican Republic and Haiti indicate that the pest is causing considerable damage, resulting in yield losses. It is suggested that there has been a second introduction into the area, this time on vegetables from China.

S. spinki attacks and damages new rice growth, causing necrosis and reduction in grain formation. Rice grains are partially filled, empty or hollow, and stained or blemished. In Cuba populations averaging 200 mites per cm^2 have been detected in rice fields, significantly reducing yield potential (Ramos and Rodríguez 1998). In addition, the Japanese have identified an association between *S. spinki* and virus particles similar to that of rice tarsonemid mite virus (RTMV). It is also reported that *S. spinki* can vector the fungal pathogen (*Acrocylindrium oryzae*) that causes grain rotting, and the mycoplasma *Spiroplasma citri* (Chow and Liu 1985).

CIAT scientists who have been monitoring this situation are in contact with collaborators in the region. CIAT's extensive collection of natural enemies of phytophagous mites could prove useful in managing this pest. Research, including host plant resistance and biological control using phytoseiid predatory mites, are planned should *S. spinki* reach Colombia.

Thrips — Two important thrips species (Thysanoptera: Thripidae) have been introduced into Colombia and Venezuela in recent years; one is becoming a serious pest of rice, and the second is causing damage on a wide range of hosts.

The rice thrips *Stenchaetothrips biformis* (Bagnall) was first reported from Venezuela in 1995 (Cermelt et al. 1995) and has since spread into Colombia and Guyana, where it is causing considerable concern among rice producers. The origin of *S. biformis* appears to be Southeast Asia and is reported as a rice pest in India, Pakistan, Nepal, Japan, and China.

S. biformis attacks both irrigated and upland rice, infecting mostly young plants. It causes yellowish lines or silvery streaks on the leaves; and plants become stunted, wilted, necrotic, and may die. *S. biformis* is reported feeding on grasses, maize, and millet. Attacks are severer on irrigated rice, and older plants suffer less damage.

***Thrips palmi* Karny** — This species has now become established in several countries in South and Central America, including Colombia and Venezuela. The pest is native of the Malaysia-Indonesia area and is now found in many areas of Asia, Africa, and the Americas. *T. palmi* has a wide host range, attacking more than 50 plant species. In

Colombia, it has become a serious pest of cut flowers and ornamentals as well as legumes and *Solanaceae* crops (Vergara 1999).

At CIAT, we are presently evaluating numerous species of predator mites (Phytoseiidae) for biological control of thrips and mite pests. Of the numerous phytoseiid species evaluated in laboratory studies, *Neoseiulus cucumeris* has given the most positive results for control of *T. palmi*. When feeding on *T. palmi*, it has the highest fecundity of any predator species evaluated on any of the phytophagus mite hosts. *N. cucumeris* also had very high oviposition and consumption rates feeding on *T. palmi*. *N. cucumeris* is also reported predating on *T. palmi* on eggplant in South Florida (Castineiras et al. 1997).

CIAT has done extensive exploration and surveys of predator mites in the Neotropics (Bellotti et al. 1994). Collections have been made from more than 2400 sites (Bellotti et al. 1987), primarily on cassava but also on other crops. Considerable species biodiversity has been identified; nearly 80 phytoseiid species have been studied and evaluated. Colonies of 15 phytoseiid species are maintained at CIAT and are available for biological control programs. Several species have already been introduced into Africa (Yaninek et al. 1993), Brazil (Bellotti et al. 1999), and Europe. A taxonomic key is being prepared in collaboration with a Brazilian colleague.

CIAT, as mentioned at the onset of this article, has traditionally researched four commodity crops, rice, beans, cassava, and pastures. More recently, CIAT's research has expanded into additional cropping systems, especially in the area of integrated pest and disease management. We are currently involved in research projects with fruits, vegetables, cut flowers, oil palm, and ornamentals, and others. Examples of this research include:

- Powdery mildew of roses, caused by *Sphaerotheca pannosa* var. *rosae*
- Bacterial blight of orchids, caused by *Erwinia chrysanthemi*
- Wilting root and crown rot of gerbera, caused by *Phytophthora cryptogea*
- Bud rot disease of oil palm, caused by *Ceratocystis paradoxa* and *Phytophthora* spp.
- Diagnosis of arthropod pest problems of asparagus
- Exploration for potential natural enemies of the Colorado potato beetle, *Leptinotarsa decemlineata* in Northern and Western South America
- Study of the bioecology of the spittlebug species complex in contrasting environments (mass rearing techniques, phenology, IPM components and management strategies).

Discussion

It is evident from the foregoing that several diseases, viruses, and insect pests pose serious threats for neotropical food crops, ornamentals, and oil palm, among others. There is an ever-growing need for coordinated regional and global efforts to study these pests and diseases before they become widespread. Among the IARCs, CIAT is in an excellent position to assume a leading position of this nature. There are well-prepared staff with expertise in these areas as well as in GIS, biotechnology, laboratory facilities, already established networks that can be built upon, a project-oriented focus that facilitates

collaboration of this nature, and good donor relations. CIAT, because of its unique geographic location and historic focus and activity in the Caribbean region can play a major role as the first line of defense against invasive pests.

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Table 1. Emergence of Whitefly-Transmitted Geminiviruses in Latin America. [1]

Year	Disease	Country	Host
1935	Cotton Common Mosaic	Brazil	Cotton
1941	Bean Dwarf Mosaic	Brazil	Common Bean
1946	Infectious Chlorosis	Brazil	Malvaceae
1954	Cotton Leaf Crumple	Mexico	Cotton
1958	Infectious Chlorosis	Brazil	Tomato
1961	Bean Golden Mosaic	Brazil	Common Bean
1965	Bean Crumpling	Brazil	Common Bean
1965	Tomato Golden Mosaic	Brazil	Tomato
1966	Tomato Yellow Mosaic	Venezuela	Tomato
1971	Golden Yellow Mosaic	Puerto Rico	Lima Bean
1971	Golden Yellow Mosaic	Puerto Rico	Common Bean
1971	Chino del Tomate	Mexico	Tomato
1977	Squash Leaf Curl	Mexico	Cucurbits
1985	Tomato Yellow Mosaic	Venezuela	Potato
1988	Bean Calico Mosaic	Mexico	Common Bean
1989	Sinaloa Tomato Leaf Curl	Mexico	Tomato/Pepper
1989	Serrano Golden Mosaic	Mexico	Tomato/Pepper
1989	Pepper Mild Tigre	Mexico	Tomato
1989	Tomato Yellow Mottle	Costa Rica	Tomato
1991	Tomato Yellow Leaf Curl	Dominican Rep.	Tomato
1991	Tomato Yellow Vein Streak	Brazil	Tomato
1995	Tomato Mottle	Puerto Rico	Tomato
1996	Texas Pepper	Mexico	Pepper
1997	Taino Tomato Mottle	Cuba	Tomato
1998	Tomato Havana	Cuba	Tomato
1998	Tobacco Leaf Crumple	Colombia	Tobacco
1998	Melon Yellowing	Colombia	Melon
1998	Soybean Yellow Mosaic	Colombia	Soybean

1. Morales, 1999

Table 2. Survey of Whiteflies and Associated Parasitoids on Several Crops in Three Colombian Departments.

Department	Host	Whitefly species	Parasitoids	Total pupae	Emerged parasitoid
Atlántico	Tomato	Bemisia tabaci	Encarsia	11	1
			Eretmocerus	8	——
			Signiphora	1	——
		Bemisia tabaci	Encarsia	168	1
			Euderomphale	49	——
			Metaphycus	2	——
Caldas	Cucumber	Trialeurodes vaporariorum	Encarsia	75	45
			Amitus	25	——
	Tomato	T. vaporariorum	Amitus	85	3
Córdoba	Cotton	Bemisia tabaci	Eretmocerus	70	5
			Encarsia	44	5
	Eggplant	Bemisia tabaci	Encarsia	69	24
Valle	Beans	T. vaporariorum	Encarsia	1336	24
			Amitus	866	——
	String Bean	T. vaporariorum	Encarsia	208	2
			Amitus	122	——
	String Bean	T. vaporariorum	Encarsia	645	74
	Tomato	T. vaporariorum	Eretmocerus	9	1

Table 3. Whitefly Species and Their Associated Parasitoid Complex Collected on Cassava from Three Geographical Regions of Colombia.

Area	Whitefly species	Parasitoid species
Atlantic Coast	Aleurotrachelus socialis	Encarsia sp. Eretmocerus sp.
	Bemisia tuberculata	Encarsia sp. Eretmocerus sp. Metaphycus sp. Trialeurodes sp. Encarsia sp. Eretmocerus sp. Tetraleurodes sp.
Valle del Cauca	Aleurotrachelus socialis	Encarsia sp. Eretmocerus sp.
	Bemisia tuberculata	——
Cauca	Aleurotrachelus socialis	Encarsia bellottii Eretmocerus sp. Signiphora aleyrodis
	Bemisia tuberculata	Encarsia pergandiella Eretmocerus sp. Euderomphale sp. Signiphora aleyrodis Trialeurodes sp. Encarsia hispida Encarsia pergandiella Eretmocerus sp.

The Subtropical Horticulture Research Station, Entomology Unit, Miami, Florida

Robert Heath
Subtropical Horticulture Research Station, ARS
Miami Florida

Introduction

South Florida is experiencing rapid changes that will severely impact agriculture in the area. South Florida is one of the primary ports of entry for imports and is a major pathway for increased invasion by exotic pests from the Caribbean and other regions. The constant threat of introduction of exotic pests and competition from foreign commodities for the U.S. market, are urgent issues facing American farmers. The following statement presents not only the current program, but also a vision for full use of the facilities staff and programs designed to meet the mission of the Agricultural Research Services (ARS) located in Miami, Florida.

Overview

The Subtropical Exotic Plant Insects Research Unit (STEPIRU) is the result of the FY 99 redirection of the Plant Quarantine and Quality Research Unit (PQQRU). Beginning in the early to mid 1980s, the mission of the unit was to find alternatives for ethylene dibromide as a quarantine treatment for mangos and other fruit coming into the U.S. from Puerto Rico, Haiti, and other Caribbean islands. Hot water and hot air treatments, as well as other strategies to mitigate quarantine issues, were developed for shipment of quarantined fruit out of Florida and for fruit coming into the U.S. from abroad. The program is being redirected from developing postharvest commodity treatments to interdiction and control/eradication of exotic insect pests of plants which enter the U.S. from the Caribbean, and Central and South America as a result of tourism and the increased trade in agricultural commodities.

The Unit will develop a research program in the Caribbean, Central and South America that will diminish the risk of foreign plant pests coming into the U.S. through Florida. Methodology will consist of collaborative efforts from entomologists and chemists within the group to study the life history, behavior, chemicals that modify behavior, and potential predators of the insect pest and to evaluate all strategies that could be exploited for development of control measures.

Additionally, the research group will collaborate with state, federal, and international scientists to ensure that our agricultural industry is protected from introduced plant insect pests. An interactive program that involves ARS-NPS, Area Office, APHIS, other federal agencies and state agencies, universities and international organizations will be established to meet the goals of the new unit. The nature of the research performed requires that new techniques and approaches be developed. Thus, a high degree of innovation, flexibility, and scientific intuition is required to select the best approach, develop the proper techniques to solve the problems encountered, and make substantial progress in a timely manner. Because known solutions to circumvent risks of exotic pest insect introductions are minimal a progressive approach will be required for each insect problem. Combinations of strategies that include detection and delimitation, use of biocontrol agents, use of biosafe insecticides and exploitation of vulnerable components of the insects' biology will have be considered and evaluated to determine an optimal solution for each problem. The results of the research will be shared by transferring new technologies to state and federal action agencies and scientists located throughout the world.

Staffing and Facilities

The proposed final staffing for STEPIRU includes a Research Leader and three Research Entomologists (these positions are funded); it is anticipated that an Insect Ecologist and Biocontrol Specialist (unfunded) will be added for a total of 6 SYs. The unit's staff will be supported by a Category 3 chemist, computer specialist, and one or two technicians for each scientist. It has also been proposed that several scientists from the Animal and Plant Health Inspection Service (APHIS) will be located at the Miami laboratory and will interface with the Unit.

Future Facilities

The preliminary design for a new facility of approximately 36,000 gsf that will be built on the Miami station is completed. The space data sheets and the space requirements summary have been prepared and define the areas of the individual functional spaces and the total areas for the new and renovated buildings on the station. This building will provide the laboratory and office spaces for the Horticulture, Hydrology and Entomology Units. The renovation of the existing horticulture building will provide offices for the station's administrative officer, an accounting technician, an office automation assistant, and a computer specialist.

Additionally, a new vehicle maintenance shop and a new vehicle storage building, each of approximately 7,000 gsf, will be constructed at a location immediately adjacent to the primary cluster of research buildings.

Existing Facilities

As part of the redirection of the Entomology Unit, considerable consolidation of personnel and renovation of existing structures has been accomplished. Additional efforts will provide a cohesive unit to meet the research goal of the Unit. While waiting on the construction of the new facility the Entomology Unit does have several structures that can house

collaborating scientists. The buildings are of interest historically and thus must be maintained. They can provide ample space and amenities for housing several research programs. Typically, the structure are approximately 900 square feet, divided into three rooms that provide ample space for a laboratory, offices, and storage. The buildings have bathrooms and controlled environments. In addition to facilities occupied by ARS, several structures are currently used by the APHIS beagle brigade, citrus canker unit, and APHIS and state pest insect monitoring group.

Rationalization for Scientific Partnership at the Miami Laboratory

In order to facilitate USDA's efforts in meeting the new challenges that face our agriculture, a close partnership between ARS and other federal agencies and state agencies, universities and international organizations is required. We intend to establish lines of communications with our clients, customers, partners, and stakeholders regarding the existence of the new unit. These include but are not limited to: ARS units in Gainesville, Ft. Pierce, Canal Point, Ft. Lauderdale, FAMU, Texas, Hawaii, California, St. Croix, Argentina, Columbia etc.; Florida and other state grower groups that are threatened by the introduction of exotic plant insect pests; Florida Department of Plant Industries; USDA APHIS and International Services; University of Florida at Homestead, Apopka, Gainesville, etc.; agriculture support groups involved in promoting agriculture in the Carribean (e.g., FAVACA, CBAG, CARDI, INRA, etc.; scientists and related agricultural organizations in the Carribean, Central and South America; and international organizations such as the UN (IAEA and FAO) and ICD.

Linkage of these entities will provide a streamlined approach to establishing methods and efforts to address problems, to develop tools, and to implement new technologies. The proposed joint effort at the Miami location will provide a timely resolution of agriculture problems that exist in the Caribbean, Central and South America that pose a serious threat to the U.S. by way of Florida. A collaborative effort in confronting insect pest problems before they arrive in the U.S. will result in a cost-effective approach that will meet the needs of our growers and state agencies and safeguard our agriculture.

Weed Risk Assessments: The Problem with Predictions

Randall Stocker
Department of Agronomy and Center for Aquatic Plants, University of Florida
Gainesville, Florida

Abstract

Non-native, invasive plant species continue to negatively impact native plant and animal communities in the Caribbean Region. In Florida, urbanization and aggressive environmental land purchasing increases the need for mechanisms to reduce impacts of invasive plants on public lands and waters. While efforts continue to develop protocols to assess the invasiveness of non-native weedy species, the limitations of these efforts must be recognized. Low base rate effect, limited field data, self-testing, and practical problems with experimental plantings are among the limitations to effective screening for current or future invasive plant problems.

Introduction

The Caribbean Region has many non-native, invasive plant species that are negatively impacting native plant and animal communities. This paper reviews efforts to formalize assessments of invasiveness and degrees of environmental impact, and predict what the next problems will be, in the context of international cooperation and trade agreements.

"Landscapers love it but conservationists curse it. In the wilds it's called a weed but in the city it graces thousands of gardens" (The Miami Herald, 27 October 1930, "Aussie Import A Pest?"). This could be a quote about many different species, although the date and location make it likely that the subject is melaleuca. This newspaper extract points out the difference between this subject area and the rest of this workshop. Potentially invasive plant species are being brought in intentionally, and principally because of actual or anticipated economic gain. Denying the introduction of these species, unlike the insect, pathogen, and other problems being discussed in this workshop, denies someone an opportunity to generate income. This means that not only do we need a framework for deciding which plants are desirable and which are not, identifying the highest priority control/eradication targets, and anticipating which new species will become problems and which will not; these must be developed

knowing that the loss of economic potential will probably encourage challenges to the decision-making framework, and the challenges may be legal instead of scientific.

Land Use Patterns

Fifty-six percent of Florida's wetlands have been developed, and thirty-two percent of upland forests have been diverted to agricultural and urban use (Martinez, 1990). But Florida is also in the midst of the most aggressive land purchasing program in the nation. The Florida legislature mandated Conservation and Recreation Lands program, Preservation-2000, and now Florida Forever are putting several hundred million state dollars annually into land purchase. Management dollars are still inadequate to control invasive pest species, although funding has been increased somewhat during the 1999 legislative session. Urbanization and land purchase can not continue at this pace very long before the realities of limited geography, budget, and growth bring the process to a grinding halt. An important question that remains, then, is: Will Florida make the financial commitment to control existing invasive pest problems, and reduce the chances of future problems, so ecologically important lands being purchased can be managed to the fullest benefit of native plant and animal communities?

Introduced Plants

Over 25,000 plant species have been brought to Florida (D. Hall, personal communication), including large numbers of food, fiber, forage, and ornamental horticulture introductions. The number vastly overwhelms the relatively impoverished native plant species list (2,523 species; Ward 1990). Fortunately, only about 4% of these introductions have become naturalized (Gordon 1998). The Florida Exotic Pest Plant Council lists 65 plant species currently impacting native habitats, and an additional 60 species that have shown a potential to do so (FLEPPC 1999). While the large size of the over 25,000 introductions should not be ignored, equally important is the 0.003 ratio of plants causing impacts to plants introduced.

Many plant species were introduced to address specific agricultural needs. *Urochloa mutica* (para grass) was introduced in many tropical and subtropical regions as a fodder grass, and was recommended for Florida pastures in 1919 (Thompson 1919). Unfortunately, this species has been considered one of the world's worst weeds (Holm et al. 1977), and was found in 52 percent of Florida's public waters in 1986 (Schardt and Schmitz 1991). *Panicum repens* (torpedo, quack, or bullet grass) was introduced for forage in the southeastern U.S. in 1926 (Tarver 1979), has also been considered one of the most serious grass weeds (17 crops in 27 countries; Holm et al. 1977), and has caused documented ecological impact (Shilling and Haller 1989). It has cost as much as two million dollars annually to control a small percentage (Schardt and Schmitz 1991) of the sites where it occurs, which include 70 percent of Florida lakes (Schardt 1994). This pest has angered agriculturist and conservationist alike; in addition to damaging wildlands, it infests citrus and golf courses (Baird et al. 1983; Fleming et al. 1978).

Concern over public land impacts of forage grasses has greatly increased the scrutiny paid to the negative consequences of weedy characteristics. However, some species such as *Pennisetum purpureum* (napier or elephant grass), with demonstrated ecological impact (Cronk and Fuller 1995), continue to be the subject of research for improved cultivars and hybrids as forage and silage in Florida (Diz et al. 1994).

Agency and Citizen Programs Related to Wildland Weed Management

Regulatory agency actions related to wildland weeds include the U.S. Department of Agriculture Noxious Weed List, the Florida Department of Agriculture and Consumer Services Noxious Weed List, and the Florida Department of Environmental Protection Prohibited Plant List. Each of these lists carries various prohibitions and penalties for non-permitted possession and plant movement.

In addition to these statutorily mandated agency rules, Florida also has the Florida Exotic Pest Plant Council (FLEPPC), which is a nonprofit, volunteer consortium primarily of federal and state agency staff working on natural resource management issues, but also including private citizens representing concerned industries (e.g., plant nursery businesses) and individual interests. Many agencies send employees to meetings of this organization as part of their normal duties, however, other agencies look more favorably on employee use of vacation time for their participation. While this organization is not chartered by state law, nor hosted by state or federal agencies, state agency funds are directed to maintain data collected by FLEPPC. These data consist of site records and plant descriptions for invasive, non-native plants found within the state.

The principal product of the FLEPPC is a biennial listing of "Category I" species that "are invading and disrupting native plant communities in Florida," and "Category II" species that "have shown a potential to disrupt native plant communities" (FLEPPC 1999). These listings have generated intense discussion and have been used to promote prohibited plant listings at the county level, but they do not describe the actual process or documentation used to determine the ecological status (Category I versus Category II) of the species listed.

IFAS Assessment Protocol

To more clearly define what is meant by terms such as "invasive" in extension publications, the University of Florida Institute of Food and Agricultural Science Deans for Research and Extension have requested faculty and citizen participation in the Invasive Plants Working Group (formerly Invasive Plants Task Force), formed in 1995. The goal of this group is to review new extension publications that are either planting guides or control manuals, and to develop an independent assessment protocol that will, in a very transparent process, indicate clearly what factors are used by IFAS to define "invasiveness" in non-native plant species.

Among the many problems associated with this effort are the enormous challenges of weighing ecological impacts in many different resource areas and determining how best to place plants in meaningful categories. For instance, is alteration of the fire regime more or less important than altering ground water flow? How much affect on the fire regime constitutes a "substantial" impact to native plant and animal communities? Is impacting fire regime always important, and to all species in the habitat, and do all species "count" the same in terms of impact? Thousands of questions materialize, and the scarcity of reliable data often requires subjective interpretation. The literature reflects the difficulties of conducting field research on the anticipated impacts of non-native plant species. "Evaluation of impacts is usually a long-term and complex process," (Virtue et al. 1999) and many answers simply will not be available until considerable field work is completed.

The practice of adaptive management adds further complexity. Current management practices favor and limit particular plant species, and favor and limit expression of "invasiveness." Management practices may change in the middle of efforts to describe invasive features of particular plant species related to those management practices. And, finally, the economic cost of invasive plant introductions, the cost of control, and the cost of doing nothing are data that are rarely available, and only now becoming the subject area of economic research.

The assessment protocol is designed for, and will be initially applied to, non-native plant species currently found in Florida. In addition to clarifying terms for IFAS publications, the protocol could help prioritize state management programs, and identify plant species that need further research.

Whatever the final form of the IFAS assessment protocol, and however it is eventually used, it is intended to clarify terms for IFAS publications and to pinpoint where additional information is badly needed, and not to compete with regulatory agency or advisory listings of plants — good, bad, or otherwise. In the interim, existing mechanisms, such as the IFAS Cultivar Release Committee, are in place to reduce the likelihood of unintentional negative ecological impact from release of non-native plant species.

Predictive Indices

It would be useful to predict, with some level of confidence, what the chances would be of future ecological damage from the release of a non-native plant species not currently found in Florida. Because there would be no body of Florida knowledge to work with, this index is much harder to create than the assessment protocol described above. Since economic harm, as the loss of potential earnings, could result from denied plant admission, the index would have to be generally reliable to withstand the expected legal assault.

Looking briefly at the world of predictions, the future is not promising. Using examples with which we are familiar, Smith et al. (1999) present and review several of the complications inherent within this field of work. If, for example, a weather forecaster is correct 90 percent of the time, we expect s/he to predict rain on 18 days in an area that receives 20 days of rain each year (90% × 20

= 18). It is, therefore, rainy on two days of predicted sunshine. Calculating accurate predictions of sunshine on 310 days [90% × (365 – 20) = 310] leaves a remainder of 35 days of sunshine on predicted rainy days. If we now substitute invasive plants for rainfall, we've predicted "no problem" for 312 plants introductions (sunny days), and later found only 2 plants (0.6%) to become problems, a percentage that might be tolerable. Unfortunately, to reach this level of effectiveness, we've predicted "problem plant" for 53 introductions, of which only 18 became problems. If we adopt the precautionary principal, excluding more plants than necessary might also be tolerable, but economic interests may not be impressed by the needless precaution in 66 percent of the "problem" cases.

Our example included 90% accuracy, with 20 rain events a year. If more realistic numbers are included that might reflect expected plant introductions, very low "problem plant" levels (0.3% of plants introduced to Florida are on FLEPPC Category I list) result in more serious public relations problems. Ninety-five percent accuracy on rainfall arriving only one day a year means no sunny days are predicted to be rainy (no "allowed" plants prove to be harmful), but only 1 out of 18 rainy day predictions actually result in rain (only 1 out of 18 plant exclusions actually were harmful plants). It seems very unlikely that economic interests would calmly abide by a 6% "problem" rate in excluded plant species.

This problem has been termed the "low base rate" effect (Matthews 1996), and has been described as it relates to earthquake predictions and weather forecasting (Matthews 1996; 1997a, 1997b). Smith et al. (1999) suggest that for Australia, "a pest risk assessment system with an accuracy of 85% would be better ignored, unless the damage caused by introducing a pest is eight times that caused by not introducing a harmless organism that is potentially useful."

Another problem is the tendency of researchers to prepare predictive indices, and then use resource-knowledgeable individuals to "test" the index. The test is how well the index predictions compare with rankings provided by individuals that should know which plants are bigger problems than other plants. The subjectivity, circular logic, and self-fulfilling prophecy potential in this process should be obvious.

Test garden approaches to assessing potential invasiveness have also been problematic, and less than satisfying (Kareiva et al. 1996). Impacts caused by invasive species often differ among the plant communities invaded, and there is usually no way of determining beforehand which communities will be invaded.

"The accuracy of a screening method in identifying invaders can only be measured after the introduction of the cohort of species, once we know which have succeeded and which have failed as invaders" (Smith et al. 1999). But what do we do if predictive indices are fraught with problems, and "[I]f we need, or want, to predict in detail the population dynamics of a particular species in a particular habitat, then there is no alternative but to study that species in detail, in the place(s) or habitat(s) of 'interest'" (Lawton 1999)?

Proposed Actions

1. Use transparent processes to define terms, and to prioritize control programs for invasive pest species.

2. Encourage field research to improve existing assessments of "invasiveness" and ecological impact of non-native species.

3. Recognize that international agreements do not allow protection of domestic markets, and that overly exclusive predictive indices may not appear very defensible under the pressure that is likely to materialize, and develop reciprocal agreements with other countries using uniform exclusion criteria that accept the high level of exclusion.

These points mesh well with the Executive Order (13112) signed on 3 February 1999 by President Clinton, which calls for reducing the introduction of invasive species, controlling the current problem species, better coordinating federal agencies, and developing a National Invasive Species Management Plan. Recognizing that current predictive indices are inadequate to address future introductions, that various assessment methods can be tested to measure their ability to categorize and prioritize "invasiveness," and that future international agreements will increase the pressure to better address invasive species issues, research and extension dollars must be increased to provide tools to manage the threat to our native ecosystems from non-native, invasive pests.

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Offshore Threats Research Imperatives Panel

Randall Stocker, Chair
Dale Meyerdirk, Mary Jo Hayes, Anthony C. Bellotti, Robert Heath, Ron Sequeira

Summary
by Randall Stocker

This panel addressed eight key issues, and identified three research imperatives and suggestions to improve the effectiveness of operational programs.

Research Imperatives

What releases invasive species? While this is certainly not a new question, it is one that still needs a great deal of attention. The most obvious factor is lack of natural enemies, but introduced biocontrol agents will always be limited to host specific organisms, which means biocontrol will not reach control levels of native range. Climate also effects weedy species and introduced biocontrol agents, so range of host specific biocontrol agents is not only factor involved.

What economic regulations can tie the management of invasive pests to the international trade that brings them? If international trade is the source of all problems, political (i.e., tax) solutions may be necessary to prevent/manage biological problems.

Improvements in basic ecological data about pests. Climate data, temperature, rainfall seasonality and amount, facilitated by Geographical Information Systems (GIS), allows much better predictions about where some pest problems might occur. These types of studies would also benefit studies being conducted on ecological analogues (e.g. between South America and Africa). More of this type of research will be needed in the future.

Operational Program Improvements

Communication among cooperators. Communication must be improved in the Caribbean Region if multi-agency cooperative programs are to effectively reduce the risk of pest problems. The current Florida medfly project shows how closely separate agencies can and do work together, but better and more streamlined communication is needed on new problems in the region, new agent

releases, survey results, results of risk assessments, and linkages with researchers. "There are still barriers, and improvement is needed to reach optimized decision-making programs" (Ron Sequeira).

There would be great benefit from a formal informational clearinghouse for new problems and introduction of biocontrol agents. You might hear about new problems and agents if you go to the right meeting, but it might be six months after the fact.

Needed: a SWAT team in the Caribbean. This might require new legislation or international efforts. U.S. Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) is asked to respond quickly in some situations (e.g. pink hibiscus mealy bug program), to set up cooperative efforts to develop control technology. USDA Agricultural Research Service (ARS) was also asked to become involved, but it took two years to get into the USDA-ARS budget cycle. The St. Croix USDA-ARS program is now very helpful, but the delay was unfortunate. A SWAT team and more flexible USDA-ARS research capability could have gone to St. Kitts to test technology and would have saved much time. This problem and the need to react quickly will repeat itself many times with new pests coming into the Caribbean, like citrus greening in Costa Rica. That problem should have been attacked eight months to a year before it came to Florida.

The large number of current problems (medfly, oriental fruit fly, citrus canker, etc.) may keep action agencies like USDA-APHIS from shifting resources to potential problems currently found in the Caribbean but not in the U.S. "Maybe we need block money that is only for working on those invasive species that are moving through the Caribbean and Central America" (Dale Meyerdirk). The effort is there at an informal level, but no formal team is set up, budgeted, and well organized with links to the Caribbean neighbors (CarCom, CARDI, IICA, and FAO).

Preclearance programs are highly desired by many countries. These programs are costly, and some countries are not willing to pay. Other countries want reciprocity, expecting preclearance for some of our exports. For instance, Mexico requires a preclearance program for U.S. apples shipped from the northeast U.S. to Mexico. Mexico cites the mango program, required by the U.S., as one reason that Mexico requires apple preclearance for U.S. shipments. Preclearance programs may be effective, but U.S. exporters will have to expect similar requirements on U.S. shipments.

Flexibility is a very important component of some effective programs. For instance, the Caribbean fruit fly-free program in Florida has been able to accommodate many diverse interests and needs, and still maintain the integrity necessary for a successful program.

Need to move from macro, abstract, concept level to the absolute, applied, local grower level. This will take advantage of the common sense practicality of the people that live with these problems every day.

Transcript

In the following transcript, panel members are identified by initials. Audience members are identified where possible.

RS — Randall Stocker
DM — Dale Meyerdirk
MJH — Mary Jo Hayes
AB — Anthony Bellotti
RH — Robert Heath
RSQ — Ron Sequeira
GG — Gary Greene

[Part of session was not captured.]

RS: … to change the way that projects are set up, possibly to be able to get more information like this out. There has to be some reason why a species becomes invasive. There must be a common thread there, whatever trips them off.

RSQ: Medfly was a very good example of how closely we worked together. I'd still say we need better communication, more streamlined communication, for the following reason:

About three days ago, we had a conference call with the NAPPO group on medfly risk assessment. A lot was said about the work done by ARS and about our ARS partners, and indeed, we worked very closely with them. As we look at this risk assessment and the information streams that are going to be utilized by us with ARS, the call is for more streamlined linkages to information.

We are dependent on whatever information is available. The more information that is available, the quicker and more comprehensive our work will be.

Returning to the example: As we proceeded in our teleconference, no mention was made of the very important work IS was conducting in Mexico in terms of the Baja California, Norte and Sud, surveys, the Chiapas activities that the IS folks had been involved with. There are gaps in information management, the integration of survey information, the regulatory survey monitoring operations, and the linkage with researchers. There are still barriers, and improvement is needed to reach optimized decision-making programs.

DM: What releases invasive species? Most of the exotic organisms coming into the United States are coming in without natural enemies. If they had their natural enemy complex from home, they wouldn't necessarily be invasive. Pink hibiscus mealy bug wouldn't have been a problem in the islands if *Antaris comallia* and *Geransporia nicca* had been present along with species already there. The mealy bug would have come in and maybe tripped the natural defenses and then dropped to a very low level. It might never have become a serious pest problem. Leafy spurge up in the north is a serious weed problem. It wouldn't have been an invasive species if we had had all the flea beetles now brought in with the cooperation of ARS and Canada, Ag-Canada. Now that the beetles have been released, leafy spurge is dropping by the wayside and native grasses are coming back in some of those areas. So, these agents coming in, they are so invasive because there are no natural enemies.

Melaleuca has 107 or so natural enemies known in Australia. If you brought all those over here, *Melaleuca* wouldn't be problem. But some of those 107 also attack other plants and so we don't want to bring all those in. So you try to reduce *Melaleuca* by using only host specific organisms; you can't use those that

can range back and forth to other plants of economic concern.

Aud.: But they also have a host range. They also feed on specific things. They probably have a climatic issue of some sort. It's more than just not having natural enemies.

Aud.: If we didn't have international trade, we wouldn't have a problem. As long as we have that, we're going to have a problem. I move something that I like into your country, and all of a sudden it may be a problem or it may not. Maybe at some point all the countries say that if you want to move things from one country to another, you're going to have to pay some tax or something that goes into research to straighten things out after you get here. It's a wider issue than just biology. The issue is a political one, a very large one.

Aud. [Waldemar Klassen]: Dale, you mentioned that what we really need in the Caribbean is a SWAT team. Two questions: Would we need new legislation or some international to put that in place? And how would research fit into that?

DM: Working on the pink hibiscus mealy bug program over the last three years has been an eye-opener for me and has introduced me to a lot of Caribbean community research organizations as well as the complications of working in different countries within the Caribbean. But I also saw that APHIS was asked to assist in this as quickly as possible to try to set up some cooperative effort that would find technology to control these pests, knowing they were probably coming toward the United States. At that time, we wanted ARS to get involved at the outset, but they have a budgeting scenario that requires them to develop a new CRIS. Two years after we originally made the request for them to join forces with us, they were able to develop money and now we have a very strong program assisting us in St. Croix. They have been very instrumental in helping us raise pumpkins on St. Croix. We've been very appreciative of that.

If there had been a SWAT team together with the flexibility of ARS research capability that could have gone to St. Kitts to try this technology, we would have been known more in advance and not had the delays on specific research efforts. APHIS is not research oriented; we're operation oriented, and we need a research arm next to us. I see a strong cooperative effort with flexible budgets and abilities to target new pests coming into the Caribbean, like the citrus greening problem in Costa Rica. We should have jumped on that eight months to a year before it ever came into Florida. But in fact, this could get the administration to agree that this is a top priority consideration.

We're fighting so many problems here in the United States — medfly, oriental fruit fly, citrus canker — you say that there's a problem in Costa Rica we ought to be thinking about. USDA is likely to say that they agree but don't have money for that. We can't afford to keep the current U.S. programs going. Maybe we need block money that is only for working on those invasive species that are moving through the Caribbean and Central America. We've got to get a handle on them before they come into the States. I see this cooperative arrangement is partially there at the ground level. But we don't have a formal team that's set up, budgeted, and well organized with links to the Caribbean neighbors — CariCom and CARDI and IICA and FAO.

I think if Mike Shannon was here he'd tell you we're totally in the dark on agents that are coming into the Caribbean. Where are the surveys and all the reports on this? If you go to the right meeting, you might hear about it, but you might not hear about it for six months. Then maybe there's been a new infestation in the Caribbean we don't even know about. I mean that's something I'm real concerned about. We're not even tying that together.

RS: Someone said: Nobody ever got elected by preventing something. So sadly in out democratic way of life over here in this hemisphere you're up against a tough one.

I'd like the members of the panel to make a brief closing statement.

GG: My name is Gary Greene. I work with APHIS International Services. I've worked in quite a few of the preclearance programs that Elena was talking about this morning.

One concern in our preclearance programs is that they are costly. Export groups and some countries really want a preclearance program, but they're not really willing to pay for it. It's causing a lot of headaches because, on one hand, they want the programs, but on the other hand, when we set up programs, some countries want reciprocity; they want the same thing for some of our exports.

Case in point: exports of apples from the northeast U.S. to Mexico. Mexico has a contingent of people up in the northeast now. It's very costly, and Mexico requires it to export apples to Mexico. Mexico cites our programs in Mexico — specifically the mango program — as one reason for this requirement. The point is that if we're going to continue to set up preclearance programs — and I think they're effective — our exporters are going to have to expect similar activities in the U.S., and they are very costly.

If you ship apples all over the world, eventually you're going to have four or five countries in Yakima, Washington exporting the same apples. They may be going to different countries, but a lot of them will be exported on the same or similar protocols.

AB: One comment on the science of invasive pests. One of the areas we're paying more attention to now is the basic ecological data about the pest. This includes climate data, temperature, and rainfall, and rainfall amount, and especially rainfall patterns sometimes. We're finding that this information is becoming more available through GIS systems. We can get much more predictive about where some pest problems might occur. We have some of the basic biological and ecological data about this. It means doing basic research on some pest problems, perhaps in regions where pests are now before they hit wherever you are. We stress this, not only on pests but also with the natural enemies.

We're doing a lot of work now on ecological analogues. We did this between the South American continent and the African continent, and are able to predict where certain natural enemies, like predators or parasites, might fit in an area. We have to pay more attention to this in the future.

MJH: I'm actually a scientist so I'm going to move off into the political world. What impressed me most about the Caribbean fruit fly-free program in the state Florida is that it's incredibly flexible. It keeps finding a way to accommodate just about everybody and still maintain integrity. We need to look at this from a political point of view. We are going to

maintain integrity, but we're going to try to include as much as possible, we're going to be as flexible as possible.

And common sense … A lot of these refinements occur because growers are asked: How did you solve this problem? Growers live with these problems day and day out.

We need to move from macro, abstract, concept level with a continuum down to the absolute, applied, to the local grower level. Often at the abstract level, the problem looks bigger than the Milky Way, but when you get it broken down, you find it's not nearly no big and, in fact, you can break it down into small enough chucks to beat it. So I think we need to consider these problems all the way down to the practical level and how we accommodate and find options that bring more and more people into the mix.

Critical Commodities in the Caribbean Basin: A Florida Perspective

John VanSickle
Food and Resources Economics Department (FRED), University of Florida
Gainesville, Florida

In Richard Brown's presentation (Critical Commodities in the Caribbean Basin: Patterns of Trade and Market Potential, this volume), he pointed out a couple of issues in international trade and invasive pests that I would like to re-emphasize and expand upon.

Trade data for 1997-98 demonstrates the importance of trade in unprocessed products which may serve as carriers of invasive pests. Trade data indicates that imports of unprocessed products into the U.S. were 20 and 23 percent, respectively, for 1997 and 1998. Fruits and vegetables accounted for almost 50 percent of those products. Those imports are unprocessed products at the point of entry into the U.S. As you look at the greater Caribbean Basin as defined by Dr. Brown, the unprocessed products that were imported from that region accounted for 38 and 41 percent, respectively, of all imports in those two years. Fruit and vegetables accounted for 20 percent of those imports. What do these numbers imply? First, there is a much larger proportion of the imports from the Caribbean Basin that are unprocessed. Imports of those products may pose greater risk for invasive pests to domestic producers. Second, those products that may serve as hosts for invasive pests are products that may be critically important to Florida agriculture.

Five Critical Florida Crops

I am going to focus on five vegetable crops that are critically important to Florida agriculture to give a sense of the impact invasive pests may have on those crops. These five crops, for which comparative advantage is important to long-term survival, are tomatoes, bell peppers, cucumbers, eggplants, and squash.

Market share trends over the last 10 years for those crops show that the U.S. as a whole has lost about 10 percent of the of the U.S. domestic market, falling from about 80 percent to 70 percent from 1990 to 1998. Market share trends in Florida have been similar, decreasing from almost 35 percent in 1990 to 25 percent in 1998. Fresh tomatoes have seen even larger declines in market share

for U.S. and Florida producers. The peak in market shares for U.S. and Florida producers occurred in 1992 when Mexico had production problems because of weather. U.S. producers supplied 90 percent of the domestic U.S. market in 1992. In the same year, Florida producers supplied 47 percent of the domestic market. Since then, market shares have declined to 67 percent for all U.S. producers and 25 percent for Florida producers. The major source of imported fresh tomatoes over the last decade has been Mexico, with Mexican producers doubling their volume of fresh tomatoes sold in the U.S. between 1990 and 1998. Other countries that have experienced growth in exports of fresh tomatoes into the U.S. are Spain, Canada, and the Netherlands.

You can see the same kinds of trends in the other crops that are important to Florida. U.S. and Florida market shares decreased over the decade of the 1990s, while imports from Mexico and other foreign producers increased. Much of this increase has taken place in the last three to four years. These trends do not surprise many analysts who work with these commodities. What drove those increases in imports is the globalization of the marketplace with lower tariffs and easier market access. The speed at which many of these changes have occurred has led to some trade disputes on some of the major commodities like fresh tomatoes and bell peppers. Those are being handled in the forum designed to remedy unfair trade practices, but the bottom line is that we are seeing an increase in trade in these particular commodities. We can expect future increase in these trade flows for two reasons: 1) There is increased demand for those products, creating opportunities for global producers, and 2) We also have new technologies that allow us to ship and retain high quality in our products.

The challenges producers face are great. Globalization of the marketplace will result in an increase in trade with Caribbean nations. That increase in trade will occur with those products that can carry invasive pests. It highlights the importance of the issues surrounding trade and invasive pests.

Globalization of the marketplace will increase our probabilities for pest infestations. The impacts that these invasive pests may have on our producers depend on the nature of the pest and the damage created by the pest. The potential impacts caused by invasive pets include the loss of product through production losses incurred by domestic producers. Many invasive pets cause damage to plants and animals and decrease their productivity. Impacts may also occur in loss of markets as other producing areas ban imports of products that are identified as at risk of carrying invasive pests. Finally, there is the cost of eradicating any invasive pests that enter producing areas at risk to the invasive pests. Certainly, those policy makers and producers who have had to deal with the Mediterranean fruit fly are sensitive to the issues surrounding the cost of eradication. The potential cost of these impacts are not known with certainty, but can be estimated through economic modeling of the production and marketing systems for those products at risk for U.S. producers. Another important measure in estimating these impacts are the probability estimates for impacts of certain pests.

The Case of Methyl Bromide

We have looked at issues similar to invasive pests and measured potential impacts on domestic producers. Methyl bromide is a critical soil fumigant for many fresh vegetables. Methyl bromide is scheduled to be phased out of use by 2005 by the Montreal Protocol, the international agreement that regulates use of the ozone-depleting substances. Banning methyl bromide without better alternatives than are known today will impact producers of fresh vegetables who rely on it for soil fumigation purposes. These impacts were estimated by evaluating the impacts that banning methyl bromide would have on the productive capacity of the land used to grow these crops. Total impacts go beyond loss of productivity however. Changes in the competitiveness within areas becomes important because the impacts are not just limited to the loss of productive capacity.

Total impacts will depend on how producers compete with their competitors within the market. Comparative advantage in each of the different producing regions may be impacted, which determines the total impact on producers. For example, it is estimated that the loss of methyl bromide will result in Florida and California producers losing more than $200 million in shipping point revenues, with Mexican producers increasing significantly because they will not be impacted by the loss of methyl bromide. This change occurs because of a loss in productive capacity and a loss in comparative advantage to Mexico. Those same issues will need to be estimated if we are to understand the overall impact that pest infestations may have in any area if proper safeguards are not implemented.

Conclusion

As we move forward with globalization of markets in the Millennium Round of WTO negotiations which will begin in December 1999, we will have increased trade flows and increased risk of invasive pest infestations. The burden of protecting domestic producers from invasive pests will grow. It is becoming more important to implement safeguards for invasive pests for our producers and also for our consumers who will share in the costs of invasive pests through higher prices for lower quality products.

Note: The following tables contain information on which this text is based. They are presented without further explanation.

Table 1. Florida, U.S. and Import Market Shares for Tomatoes, Bell Peppers, Cucumbers, Eggplant, and Snap Beans, 1990 to 1998. (In percent)

	Florida	U.S.	Imports
1990	33.6	79.3	20.7
1991	35	80	20
1992	43.6	85.7	14.3
1993	35.5	78.5	21.5
1994	33	79.4	20.6
1995	29.6	73.2	26.8
1996	26.1	70.2	29.8
1997	25.1	71.4	28.6
1998	25.5	70.1	29.9

Table 2. Florida, U.S. and Import Market Shares for Tomatoes, 1990 to 1998. (In percent)

	Florida	U.S.	Import
1990	36.1	80.9	19.1
1991	38.4	81	19
1992	47.7	90	10
1993	40	79.4	20.6
1994	35.4	81.2	18.8
1995	33.8	71.6	28.4
1996	28	68	32
1997	25.3	69.8	30.2
1998	25.5	66.8	33.2

Table 3. U.S. Imports of Tomatoes from Mexico, Spain, Canada, and The Netherlands. (In 1000 metric tons)

	Mex.	Spain	Canada	Neth.
1990	352	0	3	1
1991	353	0	3	2
1992	183	0	5	3
1993	400	0	5	7
1994	376	0	8	8
1995	593	0	12	12
1996	685	0	22	23
1997	660	4	38	34
1998	734	6	62	37

Table 4. U.S. Imports of Tomatoes from Spain, Canada, and The Netherlands. (In metric tons)

	Spain	Canada	Neth.
1990	15	3075	1194
1991	1	2671	2410
1992	2	5214	2532
1993	0	4733	7044
1994	21	7675	7547
1995	0	11658	12401
1996	0	21774	23473
1997	4440	37504	33718
1998	6498	61729	36804

Table 5. Florida, U.S. and Import Market Shares for Bell Peppers, 1990 to 1998. (In precent)

	Florida	U.S.	Import
1990	29.2	82.7	17.3
1991	27.7	85.1	14.9
1992	37.7	88.1	11.9
1993	29.3	84.4	15.6
1994	36.8	85.5	14.5
1995	25.5	82.1	17.9
1996	25.7	81.8	18.2
1997	31.1	80.9	19.1
1998	27	80.5	19.5

Table 6. U.S. Imports of Peppers from Mexico, Spain, Canada, and The Netherlands. (In metric tons)

	Sp.	Can.	Neth.	Mexico
1990	0	1398	6878	126462
1991	2	2346	8867	122423
1992	1	1840	10770	113172
1993	2	3514	17368	135312
1994	0	3838	17140	144866
1995	0	6944	17828	203969
1996	0	6553	18476	249405
1997	33	10622	18065	256478
1998	317	16528	20844	284729

Table 7. U.S. Imports of Bell Peppers from Spain, Canada and The Netherlands. (In metric tons)

	Spain	Canada	Neth.
1990	0	1398	6878
1991	2	2346	8867
1992	1	1840	10770
1993	2	3514	17368
1994	0	3838	17140
1995	0	6944	17828
1996	0	6553	18476
1997	33	10622	18065
1998	317	16528	20844

Table 8. Florida, U.S. and Import Market Shares for Cucumbers, 1990 to 1998. (In percent)

	Florida	U.S.	Import
1990	27.9	68.5	31.5
1991	31.3	69.1	31
1992	37.2	67.9	32.1
1993	29.2	65.3	34.7
1994	20.2	63.6	36.4
1995	19.3	63.8	36.2
1996	17.5	58.9	41.1
1997	16.1	62.1	37.9
1998	16.3	64	36.1

Table 9. U.S. Imports of Cucumbers from Mexico, Spain, Canada, and The Netherlands. (In metric tons)

	Sp.	Can.	Neth.	Mexico
1990	42	3295	140	166258
1991	11	3462	134	159962
1992	145	3909	186	171370
1993	218	3689	517	204422
1994	164	4143	321	228229
1995	0	5173	1045	238986
1996	0	6558	1321	293753
1997	439	10296	158	286082
1998	419	13369	249	307401

Table 10. U.S. Imports of Cucumbers from Spain, Canada, and The Netherlands. (In metric tons)

	Spain	Canada	Neth.
1990	42	3295	140
1991	11	3462	134
1992	145	3909	186
1993	218	3689	517
1994	164	4143	321
1995	0	5173	1045
1996	0	6558	1321
1997	439	10296	158
1998	419	13369	249

Economic Research Imperatives Panel

John VanSickle, Chair
Richard Brown, Sergio Oxman, William A. Messina, Philippe Agostini

Transcript

In the following transcript, panel members are identified by initials. Audience members are identified where possible.

JVS — John VanSickle
RB — Richard Brown
SO — Sergio Oxman
PA — Philippe Agostini

JVS: Our responsibility is to identify some economic research imperatives, and I'm going to start out and then ask the panel members to make a brief statement.

We go through the process that's necessary to do risk assessment, and it comes down to trying to identify probabilities. The probabilities, as well as the impacts, are important for identifying what programs or interdiction is needed. Identifying these probabilities is critically important. For example, as an economist, to run the evaluations in doing our methyl bromide work that I've been involved with over the last few years, the assumptions that feed into our model control the outputs or the predicted impacts. Our output is only as good as the input, and in this case, the input is those probabilities. From that perspective, one of the important issues that we've got to determine is how we identify those probabilities and the resulting outcomes.

SO: According to my lengthy experience working in many Caribbean countries, these small countries don't have institutional set-up; it are just isn't there. As Mr. Agostini said, the private sector feels captive because they don't have the scale. It seems that our discussions have assumed too much that we are starting from zero. There is already a lot of information and infrastructure in place If we go to the Internet CIA pages, we will find much information on these countries. There are many internationals with scientific, technical, and policy panels already set up and ready to work. But in the 90s, we were speaking about the same organizations that were raised today.

I agree with the previous speaker in terms of a task force, but it should be restricted so that there isn't duplication or repetition of effort. Everyone knows already what the research areas are, the volumes of export, the amounts, the percentages of fiscal expenditures of those countries. Let's

implement one win-win program that works and shows all the international community, the U.S., the researchers, and the countries that it's possible to join efforts after one single initiative.

RB: I've been in social science research for years, and I am still puzzled when I ask what we should do next in the Caribbean. The small countries in the Caribbean remind me of the northern U.S. where villages are dying. Communities are disintegrating from the heart out. Businesses leave because the agricultural enterprises around them are concentrated on a few farms. There aren't many people involved in the income. Disposable income is relatively small. What kind of research should we do to get economic development in these areas that are essentially dying. In the Caribbean and Central America, each country and locale has severe limitations, so the research has to focus on issues that will help those people who will remain in production, in business, in trade, and so forth.

PA: The pattern in the Caribbean, especially in the English-speaking Caribbean, is that after independence basically socialist policies have been followed. For 30 years this has destroyed agriculture. In terms of technology, research, et cetera, at the end of the 50s, beginning of the 60s, we were right there with any other tropical agriculture. Trinidad had the Imperial College of Tropical Agriculture, now the University of the West Indies, which was a world-renowned facility. In those days, the private sector was vilified, socialist policies were followed, and everything was decided by the state ministries as opposed to what was demanded by the market. Large agriculture — mainly sugar but also others — was nationalized on many islands, and went downhill. State-run agriculture does not work. And with the agriculture went the spirit.

Another difficulty in Trinidad agriculture today is finding middle management, that is to say, farm foremen, farm managers. If you learn any sort of skill, then you can do it all yourself. I've gone through dozens of UWI graduates, and out of maybe 20 of them, I've found one good one, and he doesn't much like working in the field, so he goes about one day a week. So, I have been working on agroindustrial projects now. You wouldn't believe how little cooperation there is in the islands — not only English-speaking, but Spanish, French, Dutch.

We have institutions such as CARDI, University of the West Indies, and other agencies. If you want to, you can spend half your working time attending all sorts of meetings and workshops, and achieve nothing. On a simple subject like coconut genetics, coconut breeding, we have fallen — as with many other crops — way behind. Twenty years ago, everybody who was serious about coconuts started planning projects on hybrid coconuts. In the Caribbean, it was only done in Jamaica by necessity because of lethal yellowing (the same thing you had here in Florida). Everyone else fell behind. We do a lot of coconuts, about 1800 acres, we tarted up our own program of producing hybrid coconuts. Hopefully by the end of this year we'll have out first produce. It's not done very scientifically, we do it because it has to be done.

All the massive infrastructure — ministries of agriculture, CARDI, even IICA — has discussed this coconut issue ad nauseum. And still you cannot buy a hybrid coconut in the southern Caribbean. We don't want to import any from Central America because of lethal yellowing, and certainly not from Jamaica. Trinidad is very clean; when I see the various

pests and diseases that coconut has in Brazil, I don't want to import anything from there.

So even for a simple thing like coconut ... Every island has coconut trees, but we can't get together a simple program to do research and development on such a basic crop.

Aud. [Carroll Calkins]: I just had a comment on the organic growing business. Certainly, the demand far exceeds the supply, and the organic growers love that. In fact, in Washington state, the present organic growers for apples and pears do not encourage other people to get into the market. If enough people get into organic growing, the price will come down. Soon, there wouldn't be much difference between organic and IPM-grown crops.

Aud. [Dean Davis]: About four years ago, TSTAR sponsored a workshop on value-added agriculture, and one of the untapped Caribbean markets that was identified was cruise ships. It was amazing how much agricultural product they buy. The cruise ship people that were there said they would buy from Caribbean nations if they could be guaranteed sustained quality and quantity. Has there ever been any effort to go for that market?

PA: That's a very hot subject right now, not only cruise ships, but also hotels. There are a lot of tourists in the Caribbean — Barbados had half a million a year — so it's a massive market. The cruise lines and hotels buy their produce in Miami because, as you said, the Caribbean has not been able to supply products sustainably, in the required packaging, or in the quality they want. There are various initiatives now through various organizations such as IICA. Actually, I was in Puerto Rico last September at a Caribbean food meeting where this subject would have been a main topics. That meeting would have been a start because a lot of hoteliers, cruise ship people, and producers were there. Unfortunately, hurricane Georges passed over Puerto Rico two days before the meeting, and the meeting was canceled. But there are certainly some initiatives now, and now is a big opportunity for Caribbean agriculture to get together to service the tourism market.

RB: I had a conversation about twenty years ago with a restaurant manager of a hotel in Antigua. I had dinner with him not knowing who he was until after we finished dinner when we talked over brandy and I found what was on his mind. I asked him where he bought his produce, meat, and other food for the restaurant. And he said Miami.

I asked about the local market, and he said, "Three things: First, it's very seasonal. Most of the time products are only available for a few weeks each year. Second, I'm never sure of the quality, until the produce comes in the back door. Third, I would have to get lettuce, let's say, from one grower, and other things from other growers."

So every morning he'd have one thing from one grower, and another thing from someone else. Fifteen, twenty, thirty growers maybe showing up at his door with a crate or two of this and a crate or two of that. There was no consistency in quality. On the other hand, he could call Miami and in 5-10 minutes, he got everything he needed — one call for produce, one for meats, one for something else, and he's finished ordering for the day. That's a real economic factor in a small business like a hotel that has forty, fifty, or even two hundred rooms.

One other comment on organic foods: I'm wondering how long it's going to be before there's a major incident from somebody eating organic foods.

As an example: The reason my E-mail name is Mapleman is that I have followed the maple syrup industry ever since I was a kid. A product labeled "organic maple syrup" is now appearing all over the U.S. It's a processed product. How do you get an organic product that's processed? It's nothing more than fancy molasses with the sugar left in it, you know.

I asked one storekeeper about this. She said, "Well, it's third party certified." I filled out the implications for her, "So, the syrup is produced in New England, certified by a party in Minnesota, and who knows where it's packaged or canned. It's hard to believe that somebody is hired to camp in the woods year-round to make sure that no organic fertilizer or pesticides are used in that forest, or that someone follows the product through the whole process to the time it goes into the can?" She said she didn't know about that.

I'm afraid that someone is going to get hurt, and I'm not sure what that will do to the demand for organic foods. But it's a question on my mind.

Aud. [Waldemar Klassen]: Have economists taken a look at how to make research institutions more effective and more efficient?

We've had an interesting experience in Florida. In 1990, the legislature passed the Tropical Fruit Policy Act. As a result of that act, the Florida Department of Agriculture and Community Services made an annual grant of $200,000 to the Institute of Food and Agricultural Sciences, and indeed, it gave tropical fruit growers veto power over how the money was spent. In other words, it required that scientists develop proposals and then sit down with growers. Growers became the gatekeepers, deciding whether specific projects should be done or not. If a project isn't productive one year, it won't be funded for the next year.

It's been remarkable to me. I've watched it closely because this process covers a lot of the work at my center. It's been really quite effective. We've solved a lot of problems, many of them dealing with pests, but also getting into the California market, and others. I wouldn't want to see our whole program funded that way because I think all the basic research would get short schrift, but certainly there's a place for that kind of a mechanism.

I understand that in Australian states about half of the monies are allocated by the agricultural community. Have the economists had a look at this? How can they inform us on this?

PA: Yes, I agree with you on the question of research institutions being effective and finding the right balance between basic research and applied research. Scientists want to do basic research, and farmers want more applied research.

In Trinidad, we have the Cocoa Research Unit, which is basically the descendant of the Imperial College of Tropical Agriculture's cocoa research program. There have been changes that have increased the productivity and responsiveness of this unit greatly. For one thing, I found the whole attitude changed when the previous head retired, and somebody with a different attitude was hired. He was more willing to take into account the question of applied research, ,and what farmers wanted. It's important to get the right management, the right people. Often in institutions, people go forward by seniority, and if you get the wrong people moving up

the ranks who cannot manage other people, then you'll find whole research institutions producing nothing. The way people are promoted in research institutions must get closer to the private sector in terms of human resource management.

Also, whereas before scientists were beavering away at obscure projects for years and reporting to nobody, now there is a reporting procedure every quarter.

The situation had to change at the Cocoa Research Unit. One reason is that, as a farmer and chairman, I've got strict instructions from my minister because this unit is largely funded by the government of Trinidad. But we also receive funding from international agencies and private sector organizations, corporate charter organizations in Europe, UK, et cetera, and we are answerable to them.

SO: Concerning the scientific approach, something we have not mentioned is that the small countries cannot do the research and development. They cannot handle it. They are far behind the times --- twenty, twenty-five years. They don't have the laboratories, the human capital, or the large-scale development. Developed countries, like the U.S. and in Europe, have the lead on the scientific side.

But on the other side, once an application has been developed, these procedures and new ways can be helpful and improve the income of those countries. However, an individual involved in the international arena can catch those ideas. He can quit the scientific establishment and create his own private company.

In the Caribbean, it's a matter of institutional set-up. Certainly the private sector needs to provide funds. I do not agree that everything ought to be done with government funds.

JVS: One other comment. The first thing we've got to do is bid a minimum on our average cost curve, or find some other way to be efficient with public funds. Then when your investments come in, you have opportunities to shift some focus, but it's the margin that you're operating on with these kinds of operations. It would be ludicrous to force industry to fund research and eliminate the base of government and NGO funds that bring costs down to where the average cost of doing research is near its minimum; it can't happen that way. That's why there are institutions like the University of Florida that are involved in research. You've got to have basic funding, and then allow the organizations to fund at the margin, and redirect some research that's needed for them individually. Ted, you might want to make a comment on this because this is your job.

Aud. [Ted Batkin]: I agree that there needs to be a foundation of basic science, a core unit of basic science that's publically funded. This is a responsibility of government, and then industry can supplement that basic core area by funding applied technology and applied research. The marriage of basic science from the public sector and the needs of private industry generates a successful research program. You can't have one without the other. We cannot just focus and meet the desires of the growers with applied research with that underlying, fundamental, scientific basis upon which to do the applied work.

Quarantine Treatments: Facilitators of Trade in the Presence of Exotic Pests

Guy Hallman
USDA-ARS
Weslaco, Texas

Abstract

Disinfestation treatments applied post-harvest are the last technical resort for legal shipment of agricultural commodities across quarantine barriers. A number of treatments are currently used, including fumigation, heat, cold, ionizing irradiation, pesticide dips, and wax coatings. Other treatments have been researched, including modified atmospheres and microwave, but are not commercially applied. Each treatment has advantages and disadvantages. The continued use of methyl bromide fumigation as a quarantine treatment is not certain despite recent exemptions from agreements designed to reduce stratospheric concentrations of ozone-depleting substances. Irradiation deserves increased use as a treatment because irradiated food is safe, and the treatment can be effectively used on a broad range of fresh commodities. Hot water immersion should be tried for other commodities besides mangoes. Novel treatments should be investigated because improvements in cost, ease of implementation, and commodity quality are always welcome.

Quarantine Treatments

Quarantine treatments are used to disinfest commodities of quarantined pests so that the commodities may be shipped across quarantine barriers without appreciable risk of the pests' establishment in new areas. Ideally, treatments are used only when the risk of establishment of an invasive species is unacceptably high. Non-treatment methods may be used to defuse a quarantine risk situation, such as demonstrating that the commodity in question is not infested under commercial conditions or developing a management system that reduces risk to acceptable levels before the commodity is shipped. When it is economically feasible to solve a quarantine issue using non-treatment methods, then this course of action is preferable to using a quarantine treatment. No matter how mild the quarantine treatment to a fresh commodity, detrimental effects almost always occur. Most common among these are shorter shelf-life, abnormal ripening, off-flavor, and superficial peel blemishes. Non-treatment techniques for overcoming quarantine barriers are discussed in three chapters of Sharp and

Hallman (1994). When non-treatment is not a viable option to solving a quarantine problem then quarantine treatments may be considered.

Recent international trade agreements, such as the International Plant Protection Convention, make it more difficult for countries to use pest quarantines as trade barriers. Member countries of the World Trade Organization may, at least in principal, be obligated to accept quarantine treatments and alternatives which are shown by adequate scientific research to be efficacious and safe for humans and the environment. The increased rate, speed, and variety of travel and trade in present times coupled with the loss of one major quarantine fumigant, ethylene dibromide, 15 years ago and the possible future loss of the only other quarantine fumigant, methyl bromide, leads to an increased demand for alternative quarantine treatments.

It has been argued that the availability of quarantine treatments will alleviate smuggling of fruits across quarantine boundaries. Although having quarantine treatments may reduce smuggling, it will not eliminate it. This is evident by the fact that a considerable quantity of mangoes are smuggled into the United States from Mexico despite the availability of a hot water immersion treatment. A quarantine treatment, no matter how simple and cheap, still represents an extra expense and delay and almost invariably has some detrimental effect on commodity quality, thus providing a stimulus for smuggling. Besides the availability of economical quarantine treatments which cause insignificant damage to produce, more severe penalties and augmented vigilance may be needed to reduce smuggling of agricultural produce substantially. Smuggling is a key issue to reducing the influx of exotic pests.

Commercially Used Quarantine Treatments

Quarantine treatments which are currently used throughout the world on fresh commodities are: cold storage, heated air, methyl bromide fumigation, methyl bromide fumigation combined with cold storage, hot water immersion, irradiation, pesticide dip, and soapy water-fruit wax combination. The measure of efficacy in all but one (irradiation) is acute mortality.

Table 1 (next page) compares many quarantine treatments for various factors. Comparisons are general in nature and may vary greatly under specific circumstances. For example, commodity tolerance is rated high for waxes, although waxes would not even be considered for leafy vegetables.

Cold Storage — One of the oldest and still most widely used treatments is cold storage at temperatures near freezing (-0.6 to 3.3°C) for anywhere from 7 to 90 days, depending on the insect and temperature. Cold treatment was first used on a large scale during the first Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann), infestation in Florida in 1929. Advantages of the cold treatment are its tolerance by a wide range of commodities, including many tropical fruits, and the fact that some fruits, such as apples, are stored for long periods of time to increase the marketing season anyway. Also, unlike most other treatments, cold storage can be applied after the commodities have been packed and also

in transit. The chief disadvantage is the long treatment periods. If the cooling equipment or electrical supply malfunctions for even an hour and the temperature rises above the treatment limits, the entire treatment may need to be initiated anew.

Heated Air — Quarantine treatments using heated air were also used during the first Mediterranean fruit fly infestation in Florida in 1929. These treatments expose commodities to air at temperatures in the range of 43-52°C for a few to many hours. Early treatments relied largely on diffusion of heated air

Table 1. Comparison of Various Quarantine Treatments

Treatment	Efficacy	Commodity tolerance	Cost	Speed of treatment	Logistics of application	Public and industry acceptance
Methyl bromide fumigation	Broad	Moderate	Low	Fast	Easy	High
Irradiation	Broad	High	Moderate	Fast	Moderate	Moderate
Hot water immersion	Broad	Moderate	Low	Fast	Moderate	High
Cold storage	Broad	Moderate	Low	Slow	Easy	High
Heated air	Broad	Moderate	Moderate	Moderate	Moderate	High
Modified atmospheres	Broad	Moderate	Moderate	Slow	Moderate	High
Waxes and coatings	External feeders	High	Low	Fast	Easy	High
Microwave heating	Broad	Moderate	High	Fast	Difficult	High
Methyl bromide and cold	Broad	High	Low	Slow	Moderate	High
Pesticide dip	Broad	High	Low	Fast	Easy	Low

throughout the fruit load and required 8-16 hours to perform. More recent versions force air through the fruit load and can be done in one-third the time. Speed of treatment is dependent on temperature, size of individual commodities, density and arrangement of the load, air speed through the load, and moisture content of the air. Because of the many factors affecting the speed of heating, termination of heated air treatments is usually determined when the coldest point in a fruit load reaches a prescribed temperature instead of having a set time interval as in most other quarantine treatments. Heated air treatments are generally not well tolerated by temperate fruits. They are currently used to treat mangoes, papayas,

and other fresh products imported by Japan and for papayas shipped from Hawaii to the continental United States.

Methyl Bromide Fumigation — This fumigant is used against a wide variety of pests on numerous items shipped across quarantine barriers. The advantages of methyl bromide fumigation over other quarantine treatments are wide availability and familiarity (it can be applied at packing sheds or ports of entry), ease and speed of application (most treatment times are 0.5-2 hours), and relatively low cost. For a while it appeared that methyl bromide quarantine treatments would be lost because the fumigant is considered to significantly reduce stratospheric ozone concentrations. Recently, the Montreal Protocol (international body which regulates ozone-depleting substances) exempted post-harvest quarantine uses of methyl bromide, and the United States Congress followed suit by amending the U.S. Clean Air Act in a similar fashion. However, because the use of methyl bromide is scheduled to cease for its major applications, such as fumigation of planting beds, which consume up to 90% of total production, questions concerning the future cost and supply of methyl bromide may eventually threaten its availability as a quarantine treatment.

Methyl Bromide-Cold Combination Treatments — Methyl bromide fumigation is followed or proceeded by a cold treatment in some cases (PPQ 1998). In these instances, the severity of each treatment alone is deemed insufficient to provide quarantine security. Combination treatments are invariably more bothersome to conduct than single treatments. The rationale for using combination treatments is that the commodity would not tolerate either treatment alone when done with sufficient intensity to provide quarantine control of the pest. Also, a combination treatment involving cold may be advantageous when insecticidal levels of cold storage are a normal component of the shipping process anyway. Other combination treatments have been studied but show no advantages over alternatives involving single treatments (Mangan and Sharp 1994).

Hot Water Immersion — Holding mangoes in water near 46°C for 65-90 minutes was developed as a quarantine treatment for mangoes imported into the United States to replace ethylene dibromide fumigation, which was banned as a possible carcinogen. This is a simple, economical, rapid treatment which shows promise for expansion to other situations (Hallman and Quinlan 1996). However, little research is currently done with hot water as researchers seem to prefer heated air for heat quarantine treatment of fruits. Fruit damage caused by hot water immersion has been alleviated by gradual heating (McGuire 1991).

Irradiation — Ionizing radiation provided by cobalt 60, cesium 137, or linear accelerators is an effective quarantine treatment which has a different measure of efficacy than all other treatments that have been used commercially (Hallman 1999). To provide acute mortality of insects with radiation requires higher doses than those tolerated by fresh commodities. However, radiation is very effective at stopping development or providing sterility at doses tolerated by fresh commodities, and prevention of the establishment of exotic organisms does not require acute mortality. The fact that an irradiation quarantine treatment does not provide acute mortality has

been the greatest technical obstacle to acceptance; regulators were wary of accepting produce containing live insects. But in 1995 the U.S. Department of Agriculture, Animal and Plant Health Inspection Service (USDA-APHIS) decided to accept fruit fly larvae in irradiated fruits if it was certified that sufficient radiation dose was given. In that year, papayas and later other fruits began to be shipped from Hawaii to the mainland United States for irradiation and marketing. In 1999, guavas irradiated against infestation by the Caribbean fruit fly began to be shipped from Florida to California. These are the only instances of irradiation being used as a quarantine treatment in the world presently.

Irradiation shows promise as an effective quarantine treatment for many situations, and is tolerated by many fruits, probably more than any other treatment. Like cold treatments, it shares the advantage of application after packing; whole pallet-loads can be treated at a time. However, when irradiation is applied to pallet-loads, the maximum dose absorbed by many of the fruits may be at least 2.5-3 times the minimum absorbed dose applied to the innermost fruits. Therefore, irradiated commodities must tolerate about 3 times the dose required for quarantine security. Fortunately, most fruits can tolerate these increased doses for major pest groups like fruit flies and beetles. Other important pest groups, such as Lepidoptera and mites, may require larger minimum doses (up to 300 Gy), which may, when tripled, cause problems for many fruits.

Pesticidal Dips — Insecticidal dips are used for interstate quarantines in Australia to disinfest fruits of fruit flies and other insects (Heather 1994). Many countries do not permit post-harvest insecticide applications to fresh fruits and vegetables. Insecticidal dips and sprays may be used for bulbs and seeds which are not consumed. Insecticidal dips are inexpensive and easy to apply, although residue concerns severely limit their application on commodities that will be ingested.

Soapy Water and Wax — One quarantine treatment accepted by the United States against the false spider mite, *Brevipalpus chilensis* Baker, in Chile consists of immersion of cherimoyas and limes in soapy water for 20 seconds, rinsing, and immersion in a wax coating (PPQ 1998). The wax physically immobilizes any mites that remain after washing. This type of treatment shows promise against a number of small, surface-infesting pests of fruits.

Potential Treatments

Research has been done on several other disinfestation techniques which are not currently being applied on a commercial scale, such as fumigants other than methyl bromide, modified atmospheres, microwave heating, ohmic heating, and pulsed electric field. Alternative quarantine treatment possibilities deserve further research inasmuch as improvements in cost, environmental protection, safety, efficacy, tolerance by commodities, and commercial applicability are worthwhile goals.

Modified Atmospheres — Atmospheres very low in oxygen and/or high in carbon dioxide have been studied considerably as quarantine treatments, although they have not been applied on a commercial scale save for one

pilot shipment of asparagus from New Zealand to Japan (Carpenter and Potter 1994, Hallman 1994). The general term "modified atmosphere" refers to any storage atmosphere which differs appreciably from ambient air, which is 78% nitrogen, 21% oxygen, 0.033% carbon dioxide. Thus, technology as simple as plastic-wrapped packaging usually imparts a modified atmosphere, the gaseous components of which may change over time. The more specific term "controlled atmosphere" is reserved for atmospheres which are maintained at known levels. Modified atmospheres combine synergistically with raised temperatures. For example, diapausing spider mites were killed in one-seventh of the time at 40°C when treated in an atmosphere of 0.4% O_2 and 20% CO_2 versus ambient air (Whiting and van den Huevel 1995). Modified atmosphere treatments that are insecticidal require a few hours to days to achieve high levels of mortality under ambient temperatures or higher. Under cool temperatures, they may require 2-3 weeks. It may be difficult and costly to maintain modified atmospheres during treatment. Furthermore, objectionable flavors and other problems are often associated with the ultra-low levels of oxygen (<1%) needed to kill insects (Kader and Ke 1994).

Radiofrequency Heating — Microwave heating had been proposed as a fast, uniform way to heat fruits to temperatures lethal to insects. But it has not proven to be consistent nor workable (Mangan and Hallman 1998). Still, occasional research is performed (Ikediala et al. 1999). Much successful study is needed before microwave heating could be considered a viable quarantine treatment technique.

Other Treatments — Novel treatments such as ohmic heating, ultrasound, and pulsed electric field have been investigated (Hallman and Zhang 1997; van Epenhuijsen et al. 1997; Hallman and Sastry, unpublished data). These treatments require much further work before they could ever be considered feasible treatments.

Novel fumigants, such as methyl iodide, have been considered as replacements for methyl bromide (Obenland et al. 1998). In the present climate of pesticide control, it is very costly and time consuming to get new chemicals approved, and using another fumigant on fresh fruits and vegetables seems one of the least popular possibilities.

Future Directions

Improvements in cost, safety, efficacy, implementation, and commodity quality for quarantine treatments will always be desirable goals. Ionizing radiation is a very favorable quarantine treatment which could presently be applied to a number of situations involving the most important group of quarantined pests of fruits, the tephritid fruit flies. It also looks very favorable for another important group, weevils. Irrational fears of irradiation should not be allowed to impede its implementation, for it can efficiently and safely solve many quarantine problems.

Conserving the use of methyl bromide fumigation as a quarantine treatment should be a priority. It is a familiar, broadly effective, cheap, and easy treatment to apply, though it is not tolerated by some fresh commodities. Research on the use of methyl bromide to solve other quarantine problems should not be

avoided. Even though post-harvest quarantine uses have been exempted from rules governing the phase-out of methyl bromide under the Montreal protocol, this situation could change in the future. Additionally, when field and other uses of methyl bromide, which comprise at least 90% of the total tonnage, cease the price may rise dramatically. Another scenario is that producers of methyl bromide may decide it is not profitable to continue production if sales are very low and the product is under strict regulation. In any case, the uncertain future of methyl bromide should prompt researchers to provide viable solutions to all of its present quarantine uses.

Hot water immersion has proven a viable treatment for mangoes and is used on virtually ever mango that is imported into the United States from Latin American countries. Given that treatment facilities already exist in many countries, hot water immersion should be studied for other quarantine situations. Promising novel treatments should be studied whenever possible.

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Maintaining Quality Quarantine Treatments

Roy E. McDonald
USDA-ARS-U.S. Horticultural Research Laboratory
Ft. Pierce, Florida

Summary

During any handling or treatment subsequent to harvest, horticultural commodities can be damaged. This is particularly true when commodities are subjected to some quarantine treatments required for disinfestation purposes. It is important that quarantine treatments are efficacious but do not adversely affect the commodity's quality, condition, and susceptibility to decay. If the quarantine treatment reduces the value of the commodity, then the treatment is not fully effective. In other words, any treatment that disinfests a commodity should have minimal deleterious effects on that commodity. Damage manifests itself as the loss of market quality attributes including shelf life, appearance, flavor, texture, aroma, and increased susceptibility to decay organisms.

Individual commodities will respond differently to the physical and chemical stresses imposed by quarantine treatments. Deleterious commodity responses may be conspicuous and appear immediately following treatment or only will become apparent after a storage or marketing period and include abnormal weight loss, pulp softening, peel discoloration, surface lesions, and increased decay. Some responses will be physiological in nature occurring especially in those commodities that are mature at the time of treatment but ripen after treatment. Symptoms of this response in these climacteric fruits include atypical peel or pulp color, non-uniform softening, abnormal texture, and off flavors.

Developing a comprehensive and useful rating system that describes the characteristics of product condition based on physical and physiological parameters is important. The parameters for each characteristic should be well defined and documented both in the text and in photographs so examiners can systematically and accurately describe changes. Treated and nontreated control fruit should be examined before and after treatment and after storage and/or simulated marketing conditions. Some characteristics are objectively or subjectively measured while others are determined both objectively and subjectively. The evaluation must provide for

measurable resolution for specific characteristics and for changes in those characteristics being examined. In general, the results of an effective evaluation should furnish lucid indicators that will provide sound conclusions to assist in developing recommendations.

Because consumers have become increasingly cautious about chemical treatments, substantial interest exists in physical treatments, especially the use of temperature management. It is important that treatments developed under laboratory conditions be feasible in a commercial setting. The treatment protocol must tolerate not only the variability in commodity condition, but also treatment variations which occur under commercial conditions without leading to commodity damage or insect survival.

Some of the quarantine treatments have no deleterious effects on the condition and quality of some commodities and cultivars. However, injury can occur at times with approved treatments under commercial conditions. Research seeks to further refine the currently approved treatments and to develop alternatives.

Future research should include 1) physiological and biochemical basis of damage, 2) physiological basis of conditioning phenomenon, 3) pre- and post-harvest treatments to reduce damage, 4) kinetic models to correlate biochemical indices to damage, and 5) pre- or post-harvest treatments which would reduce damage.

Treatments for Non-Fruit-Fly Pests of Quarantine Importance: Problems and Approaches

Peter Follett
USDA-ARS Pacific Basin Agricultural Research Center
Hilo, Hawaii

Introduction

Hawaii now has accepted quarantine treatments (heat, cold, irradiation, or non-host status) for 18 different fruits and vegetables including abiu, atemoya, avocado, banana, bell pepper, carambola, citrus, durian, eggplant, lychee, longan, papaya, pineapple, rambutan, sapodilla, squash, tomato, and zucchini. In all cases, quarantine treatments were developed against tephritid fruit flies (Mediterranean fruit fly, oriental fruit fly, melon fly). Although fruit flies are the most important quarantine pests, other insect and mite pests are found on or in Hawaii's fresh fruits and vegetables and have equal status with fruit flies in interrupting export shipments. Non-fruit-fly pests presently of regulatory concern on tropical fruits from Hawaii are: *Calacarus brionesae* on papaya; *Ceroplastes rubens* (red wax scale) on abiu, atemoya, and rambutan; *Coccus viridis* (green scale) on abiu and rambutan; *Cryptophlebia illepida* (koa seedworm) on lychee; *Cryptophlebia ombrodelta* (litchi fruit moth) on lychee and longan; *Eriophyes litchi* (litchi rust mite) on lychee and longan; *Dysmicoccus neobrevipes* (gray pineapple mealybug) on atemoya, longan, rambutan and sapodilla; *Ephiphyas postvittana* (light brown apple moth) on lychee; *Frankliniella schultzei* (yellow flower thrips) on rambutan; *Sternochetus* (= *Cryptorhynchus*) *mangiferae* (mango seed weevil) on mango; and *Maconillicoccus hirsutus* (pink hibiscus mealybug) on atemoya, durian, longan, rambutan, and sapodilla.

Arthropod pests can be categorized as either surface feeders or internal feeders. Surface feeders such as scales, mealybugs, thrips and mites, are usually visible with the naked eye or a hand lens, although some species or life stages may be difficult to see without a good dissecting microscope. Fruits infested with internal feeders such as *Cryptophlebia* and fruit flies may be difficult to identify from visual inspection because fresh larval entry holes or oviposition sites are nearly invisible. Surface feeders can be mechanically dislodged from fruit by high-pressure water sprays or brushes, and so fruit infested only with these pests may not require the development of a quarantine treatment per se. Fruits attacked by

internal feeders require a penetration treatment such as heat or cold, or irradiation. We are exploring various approaches to ensure quarantine security for tropical fruits and other fresh agricultural products considering the pest complex. A look at several non-fruit-fly quarantine pests in Hawaii illustrates some of the problems we have encountered and the approaches we are taking to ensure quarantine security in future fruit exports.

Cryptophlebia spp.

Biology — Two species of *Cryptophlebia* (Lepidoptera: Tortricidae) attack fruits in Hawaii: *Cryptophlebia illepida*, a native Hawaiian species known as the koa seedworm, and *Cryptophlebia ombrodelta*, an Australian import called the litchi fruit moth. Both species are regulatory pests of lychee and longan, but recently they been found infesting rambutan, also. All three are poor hosts. *Cryptophlebia* is an internal feeder and multivoltine. Eggs are laid singly on the fruit surface and newborn larvae bore through the skin and feed at the skin/pulp interface. Older larvae will feed on the pulp and rarely large larvae can be found boring into the seed at the center of the fruit

Quarantine Treatments — The goal of quarantine treatments is to prevent adult emergence. Our results show a susceptibility hierarchy for irradiation and heat treatments of neonates>early instars>late instars>pupae. Our quarantine studies have focused on late instars, the most tolerant stage infesting the fruit. Hot water immersion at 49°C for 20 minutes is an approved treatment for disinfestation of fruit flies in lychee. Longan is in the process of being appended to this treatment. This treatment appears to be effective against *Cryptophlebia* spp.; we have treated 3,000 late instars with no survivors. Likewise, irradiation with a minimum absorbed dose of 250 Gy is an approved treatment for fruit flies in Hawaii. This treatment appears to kill late instar *Cryptophlebia*, also; 6,000 late instars have been treated with no survivors.

Alternative Treatment Efficacy Approach — There are obstacles to clear in developing irradiation or other quarantine treatments for *Cryptophlebia*. Our ability to rear *Cryptophlebia* will never match that of a large-scale fruit fly rearing facility, therefore conducting confirmatory tests to meet the Probit 9 standard will be difficult. The Probit 9 standard for quarantine treatment efficacy (maximum 32 survivors in a million treated individuals) was initially recommended with fruit flies and heavily infested fruit in mind. This standard may be too stringent for quarantine pests in commodities that are rarely or poorly infested. The "alternative treatment efficacy" approach measures risk as the probability of a mating pair, gravid female, or parthenogenic individual surviving in a shipment. This will be a function of many factors including infestation rate and shipment volume. The main quantitative argument for deviating from Probit 9 is low infestation rate of the commodity. Lychee, longan, and rambutan are all poor hosts for *Cryptophlebia* spp., typically having infestation rates of <1% in Hawaii. Quantitative methods have been developed to estimate the level of disinfestation treatment efficacy needed to prevent a mating pair in a shipment, and the number of insects that must be treated with no survivors to ensure quarantine security. Based

on low levels of infestation for *Cryptophlebia* in lychee, longan and rambutan and conservative estimates of shipment size, testing of approximately 10,000 individuals with no survivors may be adequate.

Mango Seed Weevil

Biology — The factor limiting the export of mangoes from Hawaii is mango seed weevil (MSW), *Sternochetus mangiferae* (Coleoptera: Curculionidae) MSW feeds only on mango. Adult females oviposit on the surface of young fruit and the first instars burrow through the pulp to the developing seed where they feed and pupate. Larval development takes 20-30 days. The long lived adult leaves the seed when the fruit falls to the ground to find protected places to overseason. Infestation levels can vary from 0-100% at sites in the same general area, suggesting dispersal is limited. Pest control research over the years has looked at field sanitation, chemical sprays (trunk and foliar), natural enemies (parasitoids, *Beauvaria bassiana*), host plant resistance, and x-ray fruit-culling technology with little success.

Quarantine treatments — A post-harvest treatment is theoretically the best way to disinfest mango fruits of MSW, but MSW has proved difficult to kill. Ethylene dibromide was not effective; methyl bromide and heat and cold treatments damage the fruit. Irradiation is the lone hope. Treatment with a minimum absorbed dose of 300 Gy is an approved dose in several countries, and we are examining this dose as a means to prevent adult emergence from fruit or to sterilize adults. The absence of an artificial diet for MSW and the longevity of the adult stage have slowed development of a quarantine treatment.

White Peach Scale

Pest status — The white peach scale (WPS), *Pseudaulacaspis pentagona* (Homoptera: Diaspididae), was collected for the first time in Hawaii in September 1997 on papaya. Its distribution presently is limited to several farms on the windward (east) side of the island of Hawaii, but its distribution is expected to expand rapidly. WPS has a cosmopolitan distribution. It is one of the most economically important scale insects in Florida and other southeastern states where it is a serious pest of peaches and other fruit and ornamental crops. Although WPS may be attacked by parasites and predators, chemical control is often required to prevent severe crop injury. WPS potentially is a threat to the Hawaiian papaya industry as a source of tree stress and fruit downgrading, and as a quarantine pest on fruit for export.

Quarantine Treatment — Currently, papayas for export from Hawaii receive a vapor heat treatment developed to disinfest fruit of tephritid fruit flies. This treatment requires that fruits be heated to a core temperature of >117°F (47.2°C) during a treatment of not less than 4 hours duration. We initiated studies to determine the efficacy of the papaya vapor heat quarantine treatment against WPS. WPS naturally infesting papayas were subjected to vapor heat treatment at one of two commercial papaya treatment facilities. Scales of the different stages were scored as dead or alive based on their color (2nd instar and adult females, termed "hardshells"), leg movement (crawlers), or ability to develop to

the next stage (eggs and 2nd instar and pupal males). Vapor heat treatment of papayas killed all 26,912 crawlers, 5,657 hardshell stage scales , 19,025 eggs, 13,618 immature male scales, and 1,049 male pupae, while untreated control survival for each life stage was generally high. Our results demonstrated that WPS on papayas subjected to the vapor heat quarantine treatment should pose no threat to quarantine security in export shipments of Hawaii-grown papayas.

Pink Hibiscus Mealybug

Biology — Pink hibiscus mealybug (PMB) (Homoptera: Pseudococcidae) was first discovered in Hawaii in 1983 infesting common hibiscus. On hibiscus, PMB was found infesting young twigs, resulting in gall-like formations on terminal growth with characteristic internode shortening, deformed leaves, and thickened twigs. Two species of encyrtid wasp — *Anagyrus kamali* and *Anagyrus sp.* — were reared from PMB soon after its discovery and are believed to have arrived in Hawaii with their host. PMB is generally thought to be under fortuitous biocontrol and has only minor pest status in Hawaii. PMB has been advancing northwest along the Caribbean archipelago and is now threatening to invade and establish in Florida, possibly without its natural enemies (but see Meyerdirk, this volume).

Quarantine Treatments — PMB is currently of interest in Hawaii because it is a federal quarantine pest and is found on several tropical exotic fruits for export including atemoya, rambutan, durian, longan, and sapodilla. Post-harvest treatments will be useful for Caribbean countries growing crops destined for export. Effective biological control will reduce PMB numbers on export crops and improve any quarantine system that includes post-harvest treatments.

We have studies in progress to develop a disinfestation treatment for PMB in Hawaii or elsewhere. PMB has a wide host range including forest trees, fruit trees, ornamentals, root crops, and vegetables. The range of PMB hosts that have export potential may have different tolerances to high temperatures and different heating properties. Therefore, rather than conduct heat sensitivity tests on PMB on one or a few natural hosts, we are conducting tests using thin agar plates. PMB readily settles and continues development on these agar plates. When agar plates are placed inside a forced hot air chamber, the agar surface rapidly attains the same temperature as the surrounding air, making it a convenient substrate for conducting heat treatment research.

Dose (time) response tests are being conducted at 45°, 47°, 49°, 51°, and 53°C on all life stages. Preliminary data suggest that the adult female is the most tolerant stage. Maintaining surface temperatures at 45°C for 2 hours results in complete kill of PMB. Less time is required at higher temperatures. Forced hot air treatment at 51°C for >20 minutes results in complete kill of PHB. More data are needed before specific surface time-temperature treatments can be recommended. By developing a set of treatments for PMB, users will be able to select the combination that best maintains the quality of their particular commodity.

Green Scale

Biology — Green scale, *Coccus viridis* (Homoptera: Coccidae), is a regulatory pest on two tropical fruits in Hawaii, abiu and rambutan. It is also commonly found on lychee, and is capable of feeding on longan. Green scale attacks many ornamentals including *Gardenia*, *Ixora*, *Zingiber* sp. (ginger) and *Plumeria*. This scale is parthenogenetic and oviparous. Eggs are laid underneath the female and hatch into crawlers that wander around the plant or disperse to other hosts. Once settled the nymphs are sedentary but can move if necessary. The adult female does not move. Green scale is a cosmopolitan pest and is common on a variety of hosts in Florida.

Quarantine System for Gardenia.— To prevent the possible spread of green scale, exports of cut blossoms of gardenia are a prohibited export from Hawaii to the U.S. mainland. A variety of quarantine treatments and control practices have been developed for green scale in Hawaii to reduce pest load in harvested commodities. These include insecticidal dips (fluvalinate and Safer's soap), hot water immersion (46°C for 30 min., 49°C for 5 min., 51°C for 3 min.), cold treatment (1°C for 5 days), irradiation (250 Gy), and in-field treatments (oil sprays). Dr. Robert Hollingsworth of USDA-ARS and Dr. Arnold Hara of the Univ. of Hawaii have recently submitted to APHIS a systems approach for quarantine security against green scale on gardenia exports from Hawaii. The systems approach involves: 1) field inspection and certification by APHIS with re-inspection every 6 months; 2) field treatment with approved insecticides as needed and mandatory record keeping; 3) a mandatory post-harvest insecticidal dip using fluvalinate and insecticidal soap; and 4) inspection of the harvested commodity by APHIS (or self-inspection by qualified growers).

Unwanted Nonregulatory Pests

Occasional pests and hitchhikers — Non-regulatory arthropods appearing on fruits can be actionable depending on the destination of shipments. For example, in February 1997 an experimental shipment of rambutan from Hawaii that had been irradiated at 250 Gy was rejected in San Francisco when *Pulvinaria psidii* (green shield scale), *Hemiberlesia lataniae* (latania scale), *Psuedococcus viburni* (obscure mealybug,), and *Cardiocondyla wroughtoni* (an ant species) were found on fruit. Although the fruit had been irradiated, no information was available on the effect of the treatment on the insects in question, resulting in shipment rejection. Two of the species causing rejection were on the list of pests associated with rambutan (green shield scale, latania scale) and the other 2 were not (obscure mealybug, *C. wroughtoni*). Therefore, the problem is twofold: information on the diversity of insects and mites found on Hawaiian tropical fruits is incomplete; and the effect of quarantine treatments on non-fruit-fly regulatory pests and other incidental arthropods is unknown. In addition, little information is available on the infestation biology (i.e., infestation rates, cultivar susceptibility, infestation phenology) of any of the non-fruit-fly pests in Hawaii. We have initiated pest surveys for rambutan, lychee, and longan to identify additional problematic species. Our situation in Hawaii mirrors that of many Caribbean countries that also need to conduct basic surveys of insect fauna.

Can Pest Management Activities Allow for Alternatives to the "Probit 9" Quarantine Treatment Requirement?

Robert Mangan
USDA-ARS-Crop Quality and Fruit Insects Research
Weslaco, Texas

Abstract

When A.C. Baker proposed the "Probit 9" post-harvest quarantine efficacy level, he specifically identified this treatment as a safeguard against fruit flies. The treatment requires that mortality is demonstrated for 99.9968% mortality level. Confirming this level at the 95% confidence level requires killing 93,613 pests with no survivors. Several studies have claimed that under many conditions such as rare infestation or low numbers of pests per commodity, this is an unreasonable requirement. A computation method was proposed that linked numbers of insects per commodity, shipment size, and post-harvest treatment efficacy to calculate the proportion of fruit that could be infested and still have an infestation of live insects below a certain level. This computation assumed that the pests had a Poisson distribution which could result by random dispersal of pests among fruit. Fruit flies are usually clustered in distribution among fruit, and the clustering tends to increase at higher infestation levels. Here I showed a calculation method that assumes clustering using standard models taken from ecological studies. The models were applied to Mexican fruit fly infestation in citrus data and used ratios of mean and variance of pests among fruit for calculation. I applied these calculations to determine either the maximum proportion of infested fruit that would be allowed to be treated for export or the severity of treatment that would be required if the infestation data were known. In most cases clustering models increased the risk of introduction and required either lower proportions of fruit being infested or increased severity of treatment when compared to the Poisson model.

Discussion

A predominant goal of fruit fly research is the prevention of introduction and establishment of fruit fly pests into non-infested regions. Improvements in technology for transport and marketing of high quality fresh fruit and vegetables are being developed which increase the probability that these pests can survive the transport of hosts. The availability of some chemical treatments and pathways to register new treatments to meet quarantine

standards that prevent spread or introduction of pests have been restricted. This situation — coupled with increased market accessibility due to changes in international trade policies, improvements in commodity transport, and changes in levels of risk of infestation that many potential importing market areas are willing to accept — has led to increased awareness and need for alternative approaches to systems that assure that commodities in commerce are free of pests.

A number of tropical and subtropical fruit fly species have long been recognized as particularly threatening due to their polyphagous larvae, reproductive capacity, and relatively rapid life cycle. The original publication by A. C. Baker (1939) proposed the "Probit 9 standard" for quarantine treatments using mortality data from cold treatments of Florida citrus against Mediterranean fruit fly as the example for calculation. The use of the probit transformation assumes that the pest has a tolerance to a stimulus such as exposure to fumigant, heat, cold, or radiation. If the stimulus exceeds a level and the response (dying) is normally distributed, then death of the pest will follow a pattern that can be expressed in the probit model. "Probit 9" is a mortality rate of 0.999968, which is 4 standard deviations above the 0.5 expected mean of a normal distribution. Couey and Chew (1986) demonstrated methods to calculate sample sizes in treatment groups to determine "numbers killed with no survivors" that correspond to different confidence intervals for various probit levels; many fruit fly treatments are based on killing over 93,616 pests as confirmation of a 95% confidence of probit 9 mortality.

Baker (1939) also recognized that pre-harvest control of pests was essential in meeting the security requirements. In the presentation here, I review some proposed methods of treating fresh fruit and integrating field control programs that reduce commodity infestation from regions with tropical and subtropical tephritid fruit fly populations that are of quarantine concern.

Quarantine treatment research has recognized for many years that some commodities cannot tolerate the severity of treatments required to achieve the probit 9 standard. Often the quality of commodities decreases at a linear rate as treatment severity increases, for example: peel discoloration in citrus treated with methyl bromide; peel pitting citrus treated by exposure to cold; stem end rot and loss of flavor in mangos treated with hot water; and lumps forming in papayas exposed to heat. It would be beneficial both to fruit quality and cost of treatment if the treatment severity could be reduced by reducing the rate of infestation. Fruit fly adults are actually quite vulnerable to many insecticides, and improvements in bait development have allowed excellent control of adult populations with relatively low rates of spray. Control programs using organophosphates applied at 10–20% insecticide at 2 to 4 liters per hectare generally reduce adult populations by more than 95%. In addition, many commodities listed as hosts for fruit fly pests are rarely infested, and survival rates in these commodities are frequently very low even when significant fly populations are present.

Approaches to Integrating Field Infestation and Post-Harvest Treatment Efficacy

The fly-fruit system can be considered one living system (immature fly) living inside another living system (the fruit). It is quite clear that a method to "count" other factors, such as host resistance and population reduction in the calculation of risk, might be used to reduce the stress on the fruit tissue required to kill a given percentage of pests. Landolt et al. (1984) presented an ecological and statistical analysis of these factors for Caribbean fruit fly (*Anastrepha suspensa*) in an attempt to justify reducing the quarantine treatment severity and concurrent damage to grapefruit from fly infested regions of Florida. In 1990, Baker et al. presented an analysis to extend the proposal by Landolt and colleagues to estimate the maximum rate (proportion) of infested fruit that would be permitted to pass through New Zealand ports after a probit 9 level treatment. A calculation method was proposed to insure that numbers of survivors were lower than a certain "maximum pest level." This same approach was developed by Mangan et al. (1998) to estimate the treatment severity required for various commodities that would be potentially infested by Mexican fruit fly for export to the U.S.

A common feature in all these calculation methods is the assumption of a random distribution of pests among individual fruit. Baker et al. (1990) recognized, that under severe post-harvest treatment conditions, the overwhelming majority of pests are killed by the treatment. At mortality levels over 99%, one would expect that most fruits with survivors would contain single individuals which would be randomly distributed among fruit. However, in our fruit samples under conditions that rely on other factors such as pesticide application or host resistance to reduce incidence of pests in imported commodities, infestation patterns will depend on the ecological or physiological factors leading to reproduction of pests in the commodity. Many of these patterns can expect to have nonrandom distributions, therefore, alternative models should be examined to determine how other distributions of pests among commodity units will impact the probability of pest introduction.

In this presentation, I propose some alternatives to the maximum pest limit models developed by from the models of Landolt et al. (1984) and Baker et al.(1990). These previous publications all depended on the Poisson distribution to estimate parameters such as treatment efficacy or infestation percentages that would be required in order to have a certain confidence that pest incidence (number of survivors per load) would be at or below a certain number per shipment. I propose these alternatives mainly to demonstrate how these estimates change when other statistical distributions of pests among fruits are used.

There are a number of distribution functions that may accurately describe the distributions of pests among commodities. The subject has been extensively discussed and reviewed in such works as Pielou (1974, 1977), Southwood (1978), Patil et al. (1971), and

Table 1. Models that can be applied to estimate the maximum proportion of infested fruit that could be permitted to enter through a quarantine with expected survivors below a maximum pest limit (mpl).

Distribution	Maximum Pest Limit Function	Calculation Parameters
Poisson	$e^{-\lambda x}\sum_{p=0}^{mpl}\frac{\lambda x}{p!}=0.95^{2}$	
Mean Crowding	$e^{-mcx}\sum_{p=0}^{mpl}\frac{mcx}{p!}=0.95^{2}$	$mc=\lambda+\left(\frac{var}{\lambda}-1\right)$
Lagrangean Poisson	$\sum_{p=0}^{mpl}\frac{\lambda x(1-g_2)!\,(\lambda x(1-g_2)+g_2p)^{p-1}}{p!}=0.95^{2}$	$g_2=1-\frac{1}{\left(\frac{svar}{s\lambda}\right)^{z}}$
Negative Binomial	$\sum_{p=0}^{mpl}\frac{\left(\frac{\lambda x}{\lambda x+k}\right)^{p}(k+p-1)!\left(1+\frac{\lambda x}{k}\right)^{-k}}{(p!(k-1))!}=0.95^{2}$	$k=\frac{\lambda^{2}}{var-\lambda+0.0001}$

Ludwig and Reynolds (1988). These references discuss biological processes that can cause nonrandom distribution of organisms among samples and mathematical methods of expressing these distributions. One important conclusion that has been presented in Ludwig and Reynolds (1988) and Pielou (1974) as well as earlier workers (Skellam 1952) is the nature of the information that can be derived from fitting observed distributions of organisms among sampling units. If the ecological, behavioral, and other factors that determine distributions of organisms are adequately defined, the best distribution function can be derived or selected. However, fitting observed frequency distributions to distribution functions cannot determine the biological cause of the observed data.

The distribution models I have selected are taken from ecological studies of insect distributions among hosts. The models are given in Table 1 along with equations for calculating specific parameters. The Poisson model assumes a random distribution of pests among individual commodities. The classic example of this distribution is the distribution of the yearly rate of horses successfully killing soldiers in the Prussian army. It is frequently applied to study the distribution of rare random events. The major advantage of this model is that the mean and variance of the frequency distribution are equal, so in the case of fruit infestation the fruit can be piled into bins, the total emerging larvae counted and the mean larvae per fruit calculated. (See Table 1.)

The mean crowding model was developed by ecologists (Lloyd 1967) to express the average number of individuals at which one individual would co-occupy a sample. If the individuals are randomly distributed so they follow a

Poisson distribution, the mean crowding and mean are equal. The mean crowding index is easily computed (shown as *mc* in Table 1). In order to compute the mean crowding, individual fruit must be held separately so the variance of larvae number among fruit can be computed. As shown in the data treated here, the variance is usually greater than the mean, so the mean crowding is greater than the mean.

The Lagrangian-Poisson (Janardan et al. 1979) model is a clumping model that corrects for this clumping when some factor such as competition reduces the infestation level in heavily infested fruit. The model has a factor (z in Table 1) to account for density-dependent effects so the impact of the variance decreases as the ratio of variance to mean increases. In this model, it can be seen that when the mean and variance are equal , the factor g_2 becomes zero and the model is Poisson. Since the processing of fruit involves culling infested fruit, a density-dependent factor is desirable. However, at present we don't have a method for measuring z. I chose –0.5 as this value because it was used in the Janardan et al. (1979) publication for seed infestation data.

The negative binomial model is also a clumping model and is widely used in ecology and sampling. This model was one of the first used by ecologists to describe distribution of animals (Cole 1949). It has been shown to represent distributions that can arise from a number of ecological and behavioral processes. Use of this model requires that the distribution actually be a negative binomial, and Pielou (1974) has shown that a number of erroneous conclusions can result when this model is applied to non-negative binomial data. I added a very small constant in this equation to keep my computer from hanging. In certain cases here, the infestation data were bimodal, that is there were two peaks of infestation that resulted in extremely high variances relative to the means. This resulted in much higher estimates of risk because the model assumed that the distribution would have a number of samples with very high numbers of pests when actually they did not exist. This model was also found to be completely unsatisfactory for estimating treatment efficacy because even at double precision calculations the model predicted negative numbers of survivors.

The maximum fruit infestation rate that can be allowed in a shipment has been the statistic of interest in past publications dealing with maximum pest limits (Baker et al. 1990). I have used similar equations to determine the treatment severity that would be required if infestation rates are known. These values can be estimated with:

n = number of units (usually individual fruit) per shipment,
m = the mean number of pests per infested fruit,
var = the variance in number of pests per infested fruit
p = proportion of fruit that are infested
M = the efficacy of post-harvest treatment.

The estimated number of pests surviving per load is the product $p \times n \times M \times m$. In our calculations, if three of these values are known, the fourth can be calculated from the distribution equations. I use μ as the product of the three known components and x as the unknown so that μx is the number of pests per

Table 2. Calculations of maximum infestation rates (live or dead pests) that would be permitted and numbers of fruit cut without infestation applying four distribution models for Mexican fruit fly for a maximum pest limit (surviving pests) of two per shipment.

Sample (Farm, Region, Date, Fruit)	Larvae/Infested Fruit			Maximum Infestation Rate (as Probability) and Number of Fruit Cut without Infestation*			
	Mean	Var.		Poisson	Mean Crowding	Lagrangian -Poisson	Negative Binomial
Llera, Tama. Dec. 1990 (Grapefruit)	6.38	14.44	Prob.	0.026	0.021	0.027	0.009
			Cut	143	172	135.15	372
Llera, Tama. Jan. 1991 (Grapefruit)	4.45	11.56	Prob.	0.036	0.026	0.047	0.014
			Cut	101	137	78	266
Llera, Tama. Feb. 1991 (Grapefruit)	3.70	4.37	Prob.	0.044	0.042	0.051	0.017
			Cut	84	88	72	215
Llera, Tama. April 1991 (Grapefruit)	4.75	17.94	Prob.	0.034	0.022	0.060	0.013
			Cut	108	171	61.27	290
Mont. N.L. 1994 (Tangerine)	1.67	1.32	Prob.	0.035	0.040	0.027	---
			Cut	104	91	136.15	---
S.J.V., B.C.S. 1992 (Orange)	8.57	50.69	Prob.	0.016	0.010	0.034	0.006
			Cut	229	360	138.12	610
S.J.V., B.C.S. 1993 (Orange)	7.36	36.36	Prob.	0.019	0.012	0.037	0.007
			Cut	197	302	93.29	523
Cand., B.C.S. 1993 (Orange)	7.48	37.33	Prob.	0.018	0.012	0.037	0.007
			Cut	200	307	99.62	531
Cand., B.C.S. 1993 (Orange)	6.45	23.43	Prob.	0.021	0.015	0.037	0.008
			Cut	172	243	99.35	453

* Model uses shipment sizes of 120,000 grapefruit, 329,000 tangerines, or 141,000 oranges per load. This corresponds to a truck trailer load shipment.

shipment. Table 1 shows four different models that are tested with citrus infestation data collected in Mexico.

The maximum fruit infestation proportion (p in this report) that can be allowed in a shipment has been the statistic of interest in past publications dealing with maximum pest limits (Baker et al. 1990). For that calculation:

$\mu = n \times M \times m$

x = p, the infestation proportion so that ($\mu \times x$) is the term used in the equation.

In these analyses, n was determined as the number of fruit per truckload entering the U.S. from Mexico and was dependent on fruit type. Grapefruit were estimated from USDA-APHIS records as having 120,000 fruit per load, tangerines as having 329,000 fruit per load, and oranges as having 141,250 fruit per load. These fruit are typically packed in 20 kilo boxes. I assumed that the treatment was equivalent to a probit 9 with survival rate at M=32/1,000,000. In all equations, the confidence factor is $(0.95)^2$ following the logic of Baker et al. (1990). Finally, I assumed that the maximum pest limit (mpl), the most live pests that would be allowed to pass through quarantine per load, is 2.

A sample analysis of the maximum proportion of infestation that would be permitted and the number of fruit that would be cut (with no infestation) per shipment to demonstrate this level is given in Table 2 for the 4 distribution models. Grapefruit were collected in a nontreated commercial orchard in Tamaulipas, oranges from "wild" trees or along property lines in Baja California, and tangerines from untreated orchards in Nuevo Leon. These samples, therefore, represent a "worst case" that may occur if field certification were to completely fail. It should be noted that all 3 states of Mexico are currently under a planned, area-wide eradication program, and these data do not represent the current situation even in unmanaged orchards.

The results demonstrate some interesting patterns. All samples had significant clustering of pests (variance > mean) among fruit except tangerines. The grapefruit and orange samples showed that the assumption of a Poisson distribution can allow higher numbers of surviving pests per shipment than when clustering is taken into consideration. The tangerine samples indicated that when distribution is more uniform (variance < mean), the Poisson assumption will be more stringent because the variance is overestimated. The negative binomial distribution cannot be used when variance < mean. The mean crowding model is more conservative than the Poisson or Lagrangian-Poisson models.

The Poisson model assumes that the mean is the same as the variance, which is not even approximately true in 8 of the 9 cases examined here. The Lagrangian Poisson corrects the excess variance by assuming some sort of density-dependent regulation, which I have assumed might happen if heavily infested fruit were preferentially culled in processing. The parameter I used ($z = -0.5$) resulted in a less conservative estimate of acceptable infestation or required treatment efficacy than the Poisson model. This would require extremely efficient culling, a pattern that is not generally known for fruit flies.

Table 3. Calculation of maximum survival rates, expressed as survivors per 1 million treated, that would be permitted applying three distribution models for Mexican fruit fly for maximum pest limit of two flies per shipment.

Sample (Farm, Region, Date, Fruit)	Larvae/Infested Fruit		Proportion Fruit Infested	Required Treatment Survivors per Million		
	Mean	Var.		Poisson	Mean Crowding	Lagrangian-Poisson
Llera, Tama. Dec. 1990 (Grapefruit)	6.38	14.44	0.008	101.52	84.74	200.67
Llera, Tama. Jan. 1991 (Grapefruit)	4.45	11.56	0.022	52.93	38.94	112.78
Llera, Tama. Feb. 1991 (Grapefruit)	3.70	4.37	0.065	21.54	20.53	25.69
Llera, Tama. April 1991 (Grapefruit)	4.75	17.94	0.060	18.18	11.47	32.19
Mont. N.L. 1994 (Tangerine)	1.67	1.32	0.010	113.17	129.41	86.54
S.J.V., B.C.S. 1992 (Orange)	8.57	50.69	0.244	2.10	1.34	6.09
S.J.V., B.C.S. 1993 (Orange)	7.36	36.36	0.046	13.02	8.48	35.84
Cand., B.C.S. 1993 (Orange)	7.48	37.33	0.205	2.88	1.88	7.94
Cand., B.C.S. 1993 (Orange)	6.45	23.43	0.057	11.99	8.51	29.72

* Model uses shipment sizes of 120,000 grapefruit, 329,000 tangerines, or 141,000 oranges per load. This corresponds to a truck trailer load shipment.

The same data are analyzed with these models in Table 3 except that I used the actual infestation rate data and calculated the required efficacy of treatment in order to have 2 or fewer pests survive per shipment. Although there is no universal maximum infestation rate accepted by trading countries except that it be very low, the standard probit 9 treatment rate requires not more than 32 survivors per million treated. The results in Table 3 suggest that in 6 of the 9 cases tested here, a probit 9 treatment would have greater than 5% likelihood of allowing more than 2 individuals to survive per load. This is not surprising because in most cases the fruit were grown with little or no insect control. However, these calculations indicate that field control is required in habitats such as these in order to meet these conditions with a probit 9 treatment.

Conclusions

I investigated models that integrate various infestation prevalence and distribution parameters with treatment efficacy to make estimates of pest survival levels. The goal of this integration is to develop sampling systems that allow for development of systems approaches that account for pest infestation levels and treatment efficacy in quarantine systems. From these analyses, I conclude that employing models that account for the pest density variance among infested fruit adds a degree of conservatism to the maximum pest limit approach. In poor hosts, such as tangerines, there is very little impact in determining the allowable infestation rate that would be permitted. In other cases such as the calculations for the oranges, a nearly 2-fold difference in this rate may result.

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Safeguarding American Plant Resources: Highlights of a Review by the National Plant Board of Relevant APHIS Programs

Dorothea Zadig
Pest Exclusion Branch, Calif. Plant Health and Prevention Services
Sacramento, California

Abstract

Technological advances, domestic market maturation, and strategic international alliances are shaping the newly emerged world economy. Borders are no longer relevant in the context of international travel and trade. The challenge now before all plant protection organizations is to find and define their role in this environment, today and far into the future. A new approach to preventing the entry and establishment of invasive plant pests (safeguarding) is needed. One that fosters development of strategies that will continue to prevent the entry in harmony with international trade obligations and opportunities while recognizing that a healthy agricultural system is dependent on a healthy natural resource base. The current U.S. safeguarding system possesses several components that, with specific modification, can meet the demands that the global marketplace has created. Specific changes that are required and the approaches to accomplish them are presented in the stakeholder review of the USDA-APHIS-PPQ safeguarding system.

Background

Historically, pest exclusion efforts have been reactive and focused on inspection at first point of entry. If a pest organism was found infesting a commodity on arrival measures were taken to destroy the shipment or eradicate incipient infestations if necessary. On arrival, measures were taken to re-export the shipment or disinfect, as necessary. As the need to exclude invasive pests became more apparent from the damage they were causing more preventative exclusion measures were developed and this strategy evolved into the comprehensive plant safeguarding system that is in place today. The cornerstone of the safeguarding system is exclusion. In turn, inspection at first port of entry has always been the foundation of the exclusion program.

Recent breaches of the United States Department of Agriculture, Animal and Health Plant Inspection Service, Plant Protection and

Quarantine (USDA-APHIS-PPQ) safeguarding system that have led to entry of dangerous invasive plant pests into the United States (US). These invasions have raised concerns that current organizational policies and procedures are inadequate to accomplish its safeguarding functions. Despite increases in resources and staffing, the current system is unable to cope with the increasing frequency of plant pest invasions. Harmful economic impacts are being experienced in increased costs of production, market access and retention, and perception of product quality (from concerns over pesticide use and residue).

Concurrently, trade expansion and technological advances in transportation that actually facilitate both survival and successful colonization, increase the chance of successful plant pest introduction. As borders have become irrelevant, so does the historical barrier approach to exclusion. Thus, a new approach is needed. One that fosters development of strategies that will continue to prevent the entry of invasive plant pests in harmony with international trade obligations and opportunities while recognizing that a healthy agricultural system is dependent on a healthy natural resource base. A new risk based management strategy based on compliance and mitigation of pest risk at origin coupled with pathway identification and surveillance can both reduce risk, support trade facilitation and expedite entry.

Central to an effective safeguarding effort is the need for a seamless process continuum by which all safeguarding activities mesh to form a net to prevent the entry and establishment of invasive plant pests. A continuum of a coordinated pre-border, border and post border approach that includes pest intelligence and mitigation at origin, preclearance, port of entry and destination inspection, and supporting detection and response activities. A continuous flow of information about pests that threaten American plant resources from abroad and likely pathways for their entry is vital for predicting regions of the U.S. that are at highest risk for invasions. Offshore, port of entry and terminal inspections to prevent entry of invasive plant pests into the country and domestic programs to detect and respond to any breach of these exclusion mechanisms.

Charge and Methodology

The USDA-APHIS-PPQ is the primary Federal agency charged with overseeing the U.S. plant safeguarding system. Recognizing the need to enhance the effectiveness of current safeguarding procedures, the APHIS-PPQ sought input from its stakeholders through a formal review process. Under a cooperative agreement with APHIS-PPQ, the National Plant Board assembled a panel of external stakeholders composed of representatives from academia, government, industry, and non-governmental organizations. The Review Panel was composed of two chairpersons and five committee chairs, as well as a project advisor and project specialist. Thirty-three external stakeholders assigned to four committees assisted the Panel. The APHIS-PPQ Steering Committee provided guidance, oversight, and logistical support throughout the review process.

As part of the overall review process, the Pest Exclusion Committee was asked to examine

the effectiveness of the current system by addressing the following questions:

- What are the most effective activities to exclude pests?
- What is the best way that offshore activities can maximize the efficacy of the safeguarding system?

Exclusion is preemptory and the most crucial of safeguarding activities, the current safeguarding system cannot meet the changes thrust upon it by rapidly transforming global circumstances, so APHIS's efficacy in this regard must change. The Pest Exclusion Committee's mission then was to positively chart a course of exclusion activities to meet these challenges. The Committee believed that ultimately its review will advance the argument that resources spent on preventing the introduction of potentially invasive plant pests by employing a strategy that's derived from a clear mission and vision rather than history will be returned many times over in safeguarding America's economy and environment.

Findings

There are 301 ports of entry (POEs) into the U.S. Existing POE operations are struggling to expand operations while new POEs are emerging each year. Between 1988 and 1993, six new POEs were established along the U.S./Mexico border. Of the 25 POEs along the U.S./Canada border, only five are monitored by agricultural quarantine inspection (AQI) staff. Yet, since 1990, imports and exports increased over 30 percent while passenger traffic doubled in volume.

Volumes of air cargo are doubling every five to six years and an increasing percentage of this cargo consists of perishable commodities such as cut flowers, fruits and vegetables. Seventy percent of the air cargo projected to enter Miami in 2000 will be perishable. The trend in all cargo movement is by way of container. Entry of containerized cargo into the Port of Long Beach, California, more than doubled between 1993 and 1997. Rail freight corridor projects to locate railheads at POEs are underway in several locations. These rail lines will create a more efficient way to quickly distribute cargo throughout the U.S. as well as the invasive pests that may be associated with them.

Based on the best available data from agricultural quarantine inspection monitoring (AQIM) data and other surveys, the pest introduction potential appears to be move from greatest to least in the following order: smuggled products, air cargo, reefer cargo, passenger baggage, and cruise ships. Information regarding the pest risk from ballast water, private aircraft and garbage remain unassessed.

AQIM survey data, for fiscal year 1998, showed that 91 percent of the estimated pounds of prohibited material missed came from sea and air cargo; the remaining nine-percent was from passenger baggage. The trend to containerize all cargo and the development of container movement strategies to expedite movement from the POE to destination, and the increased sharing of vessel container space, will continue to preclude inspection at POEs. The increased sharing of vessel container space will continue to make inspection even more problematic. The future for effective pest exclusion for

commercial cargo shipments in particular must focus on the development of effective offshore mitigation and certification strategies.

Offshore Activities

Pest risk mitigation at the point of origin, i.e., offshore, is the most viable approach to pest exclusion and mitigation. Necessary and associated activities include the identification of invasive plant pest and disease threats, development of preventative and control measures, and directed research with a mutual benefit to be received by the U.S. and the country of origin. This approach also provides a means of identifying potential high risks so that appropriate preparedness and response strategies can be developed in case of, or in advance of, an invasive pest introduction.

Offshore monitoring and surveillance should initially and primarily focus on pests and pathways associated with adjacent countries and major importing countries, that is, on countries that have significant contact with the U.S. through trade and tourism. The export of U.S. expertise in pest and disease diagnostics, surveillance, and suppression should be maximized and elevated in importance in trade facilitation negotiations. An offshore exclusion strategy that incorporates a commitment by the U.S. to assist countries in transition could provide an opportunity for the U.S. to use its expertise to identify, monitor, and mitigate currently unquantified pest risks to exclude their entry. APHIS programs to preclear passengers and cargo at origin should be expanded but not substituted or prioritized over the development of other offshore programs. The use of the preclearance approach is most suitable for countries in transition that lack the technical capability to develop and implement eradication or suppression programs.

Regionalization

As countries continue to develop international standards on a regional basis, the need to regionalize and harmonize pest exclusion strategies between countries becomes more compelling. Most compelling initially for the U.S. is the case for regionalization within North America. With thousands of miles of shared borders and large areas of similar climate and flora, an invasive plant pest that enters and establishes in one North American country may quickly endanger the others. Regionalization offers the promise of greater efficiency and shared success at excluding and managing invasive species, while facilitating a lively regional economy.

The U.S. needs to pursue harmonization of its plant quarantines and other mitigation strategies with both Canada and Mexico and develop a regional approach to pest exclusion. The U.S. has also been a leader in the development of the Free-Trade Agreement of the Americas; an upcoming agreement aimed at creating a single trading block throughout all of the Americas rivaled only in size by the existing European Union. In keeping with the proposed Free-Trade Area of the Americas, hemispheric regionalization should be pursued. Mexico is already a partner with other Central American countries toward this goal, the U.S. is already positioned to partner with the Caribbean Plant Protection Commission, the Asian and Pacific Plant Protection Commission, and the Pacific Plant Protection Organization.

Port of Entry Inspection

While port of entry inspection must continue to play and important role in the exclusion of invasive plant pests, the historic view that this activity can function, as the focal point for exclusion must be abandoned. A new risk based management strategy that requires compliance and mitigation of pest risk at origin can both reduce risk and enable expedited entry. Adequate POE inspection will require increased and expanded use of technology. Agricultural quarantine inspection (AQI) must increasingly focus on identifying new pest pathways and developing appropriate interdiction strategies. AQI and domestic program staff must be cross-trained to facilitate destination inspections.

International passenger traffic is anticipated to continually increase and will further overwhelm APHIS-PPQ's program effectiveness in excluding invasive plant pests. Education to make passengers and air carriers more aware of the potential pest introduction via this pathway (informed compliance) must be considered the most effective means to mitigate this risk. Industry involvement is crucial in developing procedures that, through education and cooperation, encourage voluntary compliance by the traveling public.

Other Exclusion Needs

Other core recommendation areas included:

- Modernization of the current system of plant quarantine laws and regulations. Legislation drafted by APHIS and known as The Plant Protection Act will realign 11 different plant quarantine laws and clarify and enhance APHIS's ability to address the risk associated with the entry of invasive plant pests.
- Harmonization of plant quarantine regulations to assure their adequacy to effectively address current and emerging invasive plant pest introduction pressures and to assure adherence to requirements of international law.
- Revision of the current civil penalty and user fee structures to provide more equitable and effective deterrence.
- Development of a collaborative process with all stakeholders in decision making.
- Revision and continuous improvement of its risk analysis functions and processes.
- Development of effective risk mitigation strategies for emerging pathways such as smuggling, transiting shipments and propagative materials.

Solely due to timeframe constraints, the Committee was unable to sufficiently examine other potential and/or emerging issues and pathways including:

- Emerging pathways, such as bioterrorism, biotechnology (genetically modified organisms, biological control agents, etc.) and the risk associated with the establishment of corporate airstrips to receive international cargo.
- The role of invasion biology.
- APHIS's role in new newly enacted Executive Order on Invasive Species.

Conclusion

The current U.S. safeguarding system possesses several components that, with specific modification, can meet the demands that the global marketplace has created. The Report is just the beginning of what will be a

long and arduous process. Just as the Review of the safeguarding system would not have been possible without the commitment, determination and perseverance of the participating stakeholders and the APHIS steering committee, designing approaches to implement the many recommendations must be a collaborative effort between APHIS and all its stakeholders.

Research and Technology Development Thrusts Recommended by the National Plant Board Study on Safeguarding American Plant Resources

Ted Batkin
Citrus Research Board
Visalia, California

This document is presented as part of a comprehensive study of the USDA-APHIS Plant Protection and Quarantine division conducted by the National Plant Board in 1999. The team consisted of 50 members of the academic community, state plant regulatory officials, and industry leaders. The Review team consisted of 4 committees to evaluate the areas of Pest Exclusion, Pest Detection and Response, International Information Systems, and Permits. The review has been accepted by the APHIS-PPQ management team and is in process on implementation of the 300 recommendations. The purpose of the review was to provide some basic direction to implementing change within the agency to meet the challenges of the future. The current mechanism of protecting the nation form invasive species is not adequate to cope with the increase in travel and trade.

Throughout the preparation of the report it became clear that there were many issues dealing with Research and Technology Development that needed to be addressed in some cohesive manner. The committees defined some areas where new technology is available outside the agency that could, and should, be adapted to the needs of APHIS PPQ activities. The background and findings of each committee are in their respective sections. In this section, the report will define some additional findings and re-state the individual needs of each committee in a comprehensive format.

APHIS and ARS have working structures that do not necessarily encourage or facilitate a comprehensive plan for safeguarding activities. There appears to be more of a competitive atmosphere for funding than a cooperative environment for achieving mutually arrived and accepted goals. When funds are channeled to APHIS Methods Development, they (Methods) tend to set themselves up in a world all their own and cross over, in the minds of ARS, into basic science research. Conversely, APHIS management expresses frustration that ARS is sometimes unresponsive to APHIS' basic research needs. Scientists in the two organizations are viewed differently within the respective groups, are evaluated differently, and follow different systems for

advancement. While some scientists and labs enjoy excellent field-level cooperation, these general views accelerates the competitive nature of the system and the agencies quit communicating effectively. There have been some very positive results from collaboration between APHIS and ARS in the area of quarantine treatments and exotic fruit flies. This success needs to be expanded to other research priorities.

APHIS-PPQ deserves credit for efforts to ensure full integration of the Methods labs and their contribution to the following goal areas: pest exclusion, pest detection, pest eradication, and long-term pest management (mainly biological control). For example, APHIS has established a National Center for Plant Health, Science and Technology (NCPHST) board of directors to provide input and guidance into project direction and funding for all APHIS Methods Development laboratories. While mainly comprised of APHIS headquarters staff and center directors, a representative of the National Plant Board and the North American Plant Protection Organization - U.S. Industry Advisory Group

The following recommendations were put forward by the Review Team as ways to improve the communications and science based decision mechanisms used by APHIS.

1 Establish a mechanism for determining research priorities within APHIS that includes representatives from the regions, International Services, headquarters staff, and stakeholders that are involved with the action programs. Stakeholders should include representatives from academic research institutions and industry.

This is to expand the current vision of APHIS-PPQ to include issues important to all stakeholders. One of the problems identified by the Review Team was that PPQ has become too inward in their thinking and is not always responsive to the needs of the stakeholders.

As a component of Recommendation #1, adopt a specific project selection process that evaluates proposed research relevance to APHIS' mission and resources. This process should allow for more objective project evaluation prior to NCPHST board funding decisions.

Again this is an expansion of the task of evaluation of critical research needs. It involves the National Center for Plant Health Science and Technology in the process.

2 Expand the NCPHST Board of Directors to include a representative of ARS and, if feasible, additional stakeholders.

The current Board for the Center needs to be expanded to generate a better working relationship with the Agricultural Research Service and a wider list of stakeholders.

3 Develop cooperation between agencies within USDA, other Federal agencies, academic institutions, and industry research organizations to discuss the research priorities established by the agency and determine the best course of action to meet the needs.

One of the roles of the CPHST should include fostering a closer working

relationship with existing research agencies. This will allow for more research programs within current budget restraints.

4 Formulate a comprehensive plan from the two steps outlined above to execute the necessary research programs. This plan should take advantage of all available resources, including outside funding sources. APHIS should be the agency to hold the system accountable for meeting the research and technology development goals.

5 Clearly define Methods Development's role in the safeguarding system to prevent the continuation of the competitive atmosphere that currently exits between USDA agencies.

This is one of the major challenges for the Director of CPHST. Methods Development has been effectiveness has been reduced through budget restraints and by some lack of clear direction.

6 Restore funding levels and resource allocations to APHIS Methods Development to concentrate on their assigned task of putting useable tools in the hands of the action agencies. Implement a strategy in line with industry standards of allocating a percentage of the budget to Research and Technology Development.

7 Encourage international cooperation and information sharing through participation in international technology development programs and seminars. Become more involved in providing leadership to the international research environment to take advantage of knowledge gained in other areas of the world.

The following list represents the specific research and technology development needs outlined by the committees:

- Improve x-ray systems for passenger luggage screening and full container cargo screening.
- Improve diagnostics systems for rapid pest and disease identification.
- Expand understanding of the use of irradiation systems in quarantine programs.
- Continue development of new quarantine treatments as current tools are phased out.
- Develop new eradication tools for current programs to replace existing methods that are controversial or may be phased out through FQPA.
- Develop eradication tools for potential invasive organisms based on risk analysis programs.
- Clearly identify the fitness of tsl strains of the Mediterranean fruit fly currently planned for expanded production and deployment in Sterile Insect Technique (SIT) programs to assure compatibility with the intended environment for release programs.
- Expand the capacity of U.S. sterile fruit fly rearing facilities and seek new collaborations with international sources.
- Expand and improve the use of detector dog technology. Investigate the feasibility of cross training canines currently in use by other agencies.

- Continue to develop improved detection tools for invasive species based on risk analysis programs.
- Expand and develop methods of spatial tracking of current pests and diseases through the use of GPS and GIS analytical systems.
- Explore the development of improved quality control tools. (need to further define)
- Establish specific goals for technology transfer of new discoveries for ultimate application in emergency response programs. Technology transfer is defined as the process used to move information from basic research through the analysis phase to final application.
- Continue to explore the use of biotechnology in improving detection and response systems.
- Establish a system of studying the biology of invasiveness and incorporate this information in the development of risk analysis strategies, pest exclusion systems, and research program strategies.

Conclusion

The Safeguarding Review can provide a road map for the restructuring of APHIS-PPQ that will improve efficiency and move the agency into the 21st Century with an action plan designed to meet the challenges. How the agency treats this change and faces the new opportunities will reflect on how the country will survive the consistent threats of new invasive species.

Recent trends in market regionalization, market globalization, open trade policies, and open markets facilitate trade of agricultural

Preliminary Assessment of Training and Technical Assistance Needs of Caribbean Nations in Strengthening Phytosanitary and Quarantine Practices

Alberto Pantoja
Department of Crop Protection
University of Puerto Rico, Mayagüez Campus

Introduction

Recent trends in market regionalization, market globalization, open trade policies, and open markets facilitate trade of agricultural commodities. However, the increased market volume also implies increased risk for pest introduction and increased levels of tolerance. On the other hand, resource limitations, downsizing, and continuous reorganizations of agricultural quarantine and inspections programs are in opposition to the increased market trends. The expected outcome could be an increase in the number of pests introduced and established in the region. In small Caribbean islands this problem is underscored by abundance of entry points, reduced phytosanitary personnel, limited access to technology and literature, and lack of databases for pests in the region.

Knowledge of Caribbean Islands strengths, weakness, and training needs will help to determine threats to American plant resources, where they exist, and what impact they could have if they enter the United States. In this work, we present a preliminary analysis of training needs on quarantine in plant protection in the Caribbean Islands. The information is based on a fast survey and phone interviews with phytosanitary personnel on the islands and interviews with USDA-APHIS-PPQ personnel in the foreign service, that have knowledge of phytosanitary issues on the islands. The survey indicated strength and weakness in the region.

Strengths and Weaknesses — Personnel

There are entomologists, plant pathologists, and experts on a few other disciplines (virology and nematology) in most countries. However, in many instances, the scientists are present in the country but not accessible to quarantine officials at the port of entry. Usually experts with a degree in a relevant discipline are associated with universities and research centers. The experts provide "consulting services" to quarantine personnel, but the response might not be as fast as needed. Additionally, experts are scattered at

different locations, thus increasing the difficulty of arranging a consultation.

In many islands, there is lack of personnel with degree in relevant disciplines. The inspectors usually have training for preliminary diagnostics, but cannot provide a positive pest identification, especially on exotic pests. Additionally, there are few experts in disciplines such as virology, weed identification, and nematology. There is a strong emphasis on insects and diseases while little importance is given to invasive weeds and other organisms such as snails, viruses, and nematodes.

With a few exceptions, there is a lack of confidence in phytosanitary certification among countries in the region. In many instances, lack of personnel does not allow for thorough searches on inspected produce.

Most countries are reactive; they take action only after a pest is detected and established in the country. The little knowledge in detection methodology and tools for exotic pests is a problem in most countries. The lack of databases and information on the geographical distribution of pests reduces the capability of detecting problems from infested areas.

There is a lack of databases for Caribbean pests. Furthermore, there are few comprehensive lists or databases for pests present in each country. A few countries have reference collections (insects, weeds,) but the collections are not well kept or collection data is unavailable. Additionally, the collections are usually associated with universities, thus unavailable to inspectors at the point of entry. The lack of biological data (life history, host list, natural enemies, pest status, geographical distribution) is evident, even for strategic pests in the region. Additionally, there is a lack of relevant literature on exotic and endemic pests in the region.

There is limited access to technology. In a few islands, even X-ray machines are lacking in airports, thus detection depends on visual/manual inspections.

Inspectors at the port of entry have limited or no access to electronic search media (Internet).

The port of entry is still the focal point of pest exclusion, but there is an increasing movement of non-registered and illegal movement of agricultural goods and passengers among islands. Even in the United States territory, boats with illegal immigrants are not reported to APHIS-PPQ inspectors, even if raw vegetables and fruits are detected.

There is a need to focus on natural resource protection. Most programs will protect agriculture while little attention has been given to the introduction of invasive weeds and pests that might affect nonagricultural areas.

Training Needs

In general, there are training needs in all aspects of quarantine, but a few critical areas are listed below:

- Detection methodology and tools
- Trapping and surveillance
- In-service training (study tours)
- Public and farmer awareness programs
- Management of internationally introduced organisms (usually there is little post-entry

evaluations of organisms introduced by universities and research centers)

- Eradication procedures
- Establishment of pest free areas
- Pre-departure clearance procedures
- Diagnostic protocols for exotic pests
- Development and implementation of post entry evaluation protocols
- Use of electronic search and database use
- Pest-risk assessment

Other Relevant, Non-training Related Issues

The United States, through the USDA-APHIS-PPQ interception reports, has a large database that is not available or is difficult to access. Access to the USDA-APHIS-PPQ files can help to build up a database for pests in the region and pest movement among islands. The information needs to be organized or made available in a user-friendly format.

Because weeds are usually identified by the inflorescence, weeds may establish and disseminate before detection; by the time of identification, eradication opportunities are much reduced. Pictorial keys for weed identification in the early stages of plant development can help in early identification and eradication programs.

An Assessment of the Plant Health System in the Caribbean

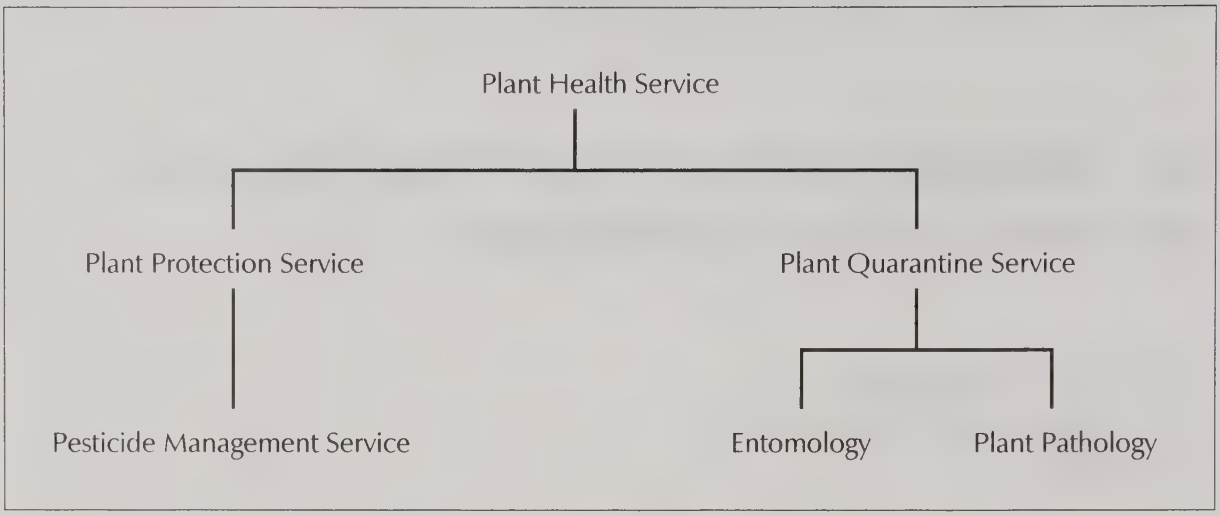
Everton Ambrose
Technical Cooperation Agency, IICA
St. Lucia

1.0 Introduction

For the purposes of this paper, the Caribbean comprises the countries in the archipelago, stretching from the Commonwealth of The Bahamas in the north to Guyana and Suriname in the south, which are members of the Caribbean Region of the Inter-American Institute for Cooperation on Agriculture (IICA). The countries are Antigua and Barbuda, Bahamas, Barbados, Dominica, Dominican Republic, Grenada, Guyana, Haiti, Jamaica, St. Kitts/Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, and Trinidad and Tobago (See Frontispiece). The Plant Health System is the organization in the country responsible for preventing the introduction of exotic pests and diseases (pests) injurious to plants and for controlling the existing pests in the country. Pesticide management is also included in the plant health system of some countries. A country's resources would be devoted to activities geared to achieve these objectives.

Developments in international trade, as a result of globalization of markets, have made it necessary that the countries examine their phytosanitary status. The World Trade Organization (WTO) Agreement on the Application of Sanitary and Phytosanitary (SPS) Measures mandates signatories to adopt guidelines and requirements for agricultural trade. A country's responsibility for protecting itself and its trading partners from pests becomes more demanding as the level of international trade in agricultural products increases in volume and complexity. Thus, countries need to ensure that measures are in place to meet these requirements. At the same time, the SPS Agreement ensures that the requirements are based on accurate scientific data. This paper outlines the status of the plant health system in the Caribbean.

Figure 1. Structure of Plant Health System



2.0 The Plant Health System

2.1 Plant Health Service

2.1.1 Legislation

There must be a Plant Health Organization with control over the phytosanitary status of plant and plant products in international trade.

The existence and function of a Plant Health Service is mandated in the legislation. The Plant Protection Acts of Dominica, Grenada, and St. Lucia and more recent acts make provisions for such a service (Table 1). The acts in these countries, except Dominica, also make provisions for the appointment of a Plant Protection Board to assist in decision making. However, in the other countries, the authority is given to the Chief Agricultural Officer or the Chief Quarantine Officer. The Acts make provisions for the controls of the movement of plant material, requiring permit for the import of the material, the implement surveys and controls including emergency actions against pests, and the certification of exports. The acts in most of the countries are out of date whilst those countries with updated acts have no regulations or the regulations are incomplete. The St. Lucia legislation is the most complete one and is being reviewed by the International Plant Protection Convention (IPPC) Secretariat with a view of developing a model for the Caribbean countries.

2.1.2 Structure

All the countries have established Plant Health Services, which carry out the provisions outlined in the law. However, their structures vary depending on the country. In some countries (Antigua and Barbuda, Bahamas, Dominica, Grenada, St. Kitts/Nevis, St. Lucia and St. Vincent and the Grenadines), the Plant Health Service comprises a Plant Protection and Quarantine Unit in which the same staff is responsible for quarantine, plant protection, and pesticide management functions (Fig. 1). In the others, the functions may be separated.

Where the functions are separated, plant protection provides research support to plant quarantine and pesticide management, which perform a purely regulatory role. Pesticide management may or may not be the responsibility of the plant health service, as for example, Jamaica, where pesticide management is the responsibility of the Ministry of Health. Support for some of these functions may be obtained from other institutions in the countries. In both cases, the duties and responsibilities are clearly spelled out.

2.2 Operations

2.2.1 Internal

Survey and detection programs are being been undertaken for major pests at the time of detection in other countries. However, many countries (Table 2) undertake regular monitoring programs for specific quarantine pests. For example, Grenada and St. Vincent and the Grenadines maintain an active fruit fly monitoring program, which meets the standards set by United States Department of Agriculture (USDA) as a condition for fruit-fly-free status. A pest list is available in most of the countries but this is incomplete. Reference collections, where present, are generally incomplete, are not maintained properly, and, in most cases, consist mainly of specimens of an entomological nature.

All the countries undertake some form of risk analysis to issue phytosanitary certificates and take decisions for the entry of agricultural produce, but they do not record these decisions nor is there a Pest Risk Analysis Unit to undertake this. Although a model emergency action plan for the entry of exotic pests is available and has been introduced in all countries, only Guyana and St. Lucia have a written plan. Furthermore, none of the countries has a written emergency action plan for any major quarantine pests. Information on pest interceptions is being provided to the countries mainly through the Food and Agricultural Organization/Caribbean Plant Protection Commission (FAO/CPPC) Newsletter and the IICA Plant Health Reports. The information in both reports is based on reports received from the countries. These ports however are not always frequent enough to influence timely decisions. Not many countries have an WTO/SPS Enquiry Point (Table 3).

2.2.2 Port

In the Bahamas, the Animal and Plant Health Inspection Unit is responsible for both animal and plant health at the ports of entry.

Sanitary and phytosanitary operations at the ports of entry are divided in all the countries except the Bahamas, but there is excellent coordination and collaboration between plant and animal quarantine. In some countries (Jamaica, Dominican Republic) both animal and plant quarantine officers are at the ports. In the other countries, the officers are cross-trained so that the two different officers do not visit or are stationed at the ports but the appropriate officer is alerted when required.

The number of designated ports of entry (air, sea, and land) varies by country (Table 4). Not all the ports are manned, but with the collaboration of other agencies (customs, police, port authority, coast guard) and the public including the shipping agents,

quarantine operations are undertaken. In this situation, the Plant Quarantine Officer visits an unmanned port at specified times or when requested by customs or the public. Additionally, in some countries, the Plant Quarantine Officer receives a copy of the carriers' manifest in order to time port visits. In most cases, the decision to man a port is determined by the level of traffic at that port.

All countries try to control the disposal of international garbage but this is a problem especially with the tourist boats and yachts. However, confiscated material is destroyed by burning, either in drums or incinerators where these are present. In many of the countries, international garbage is disposed of at inland disposal sites, many of which are not properly maintained. In Grenada, a protocol has been developed for the proper in-country disposal of international garbage. Countries are now accepting international garbage and therefore will need to follow Grenada in the development of protocols.

Except for Jamaica, Trinidad and Tobago, and Guyana, there is no obligation for travelers to declare plant produce, since no customs declaration form is used. However, all the countries issue a phytosanitary certificate for the certification of exports. Import permits are required for the importation of planting material. Except for Jamaica, where a USDA inspection manual is used, inspectors at the ports generally do not have inspection manuals, thus there is no uniformity in inspection. Such a manual was recently developed by FAO and is to be distributed to the countries. The Dominican Republic is also developing an inspection manual.

2.3 Resources

2.3.1 Facilities (Table 5)

2.3.1.1 Post Entry Quarantine — A Post Entry Quarantine Facility (PEQF) is present in Jamaica. It consists of three security glass houses, a propagation house, a screen house, an incinerator, a fumigation chamber, and ancillary structures. The PEQF in the Dominican Republic consists of a fumigation chamber and 12 security houses. Both of these facilities are underutilized. Trinidad has one sealed glass house. Barbados is used as an intermediate quarantine station for the entry of cocoa germplasm into the region as the country is not a cocoa producer. None of the other countries have PEQF.

This facility however is expensive to maintain and would not be cost effective in these countries. New genetic materials could be sourced from pest-free areas or a post-entry quarantine station identified through pre-export inspection certification system. With such a system only a screen house would be necessary in each country. A report (Ambrose 1993) on the feasibility of operating the PEQF in Jamaica as a regional facility revealed that the countries were unwilling to fund the operations of this facility.

2.3.1.2 Port Facilities — Port facilities vary within countries. Most countries have an office at one of their ports. The office equipment may vary from a desk and chair (Antigua and Barbuda, St.Vincent and the Grenadines) to a fully equipped office with refrigerator, running water, inspection bench, examination equipment (microscope, hand lens, pins, knife) as in Grenada, Guyana, and

Jamaica. Most countries have a security bin for storing confiscated plant material.

2.3.1.3 Equipment and Resources — Not all quarantine inspectors have basic equipment such as hand lens, torchlight, and knife. Some supervisors complain that officers are given the equipment but do not take care of them. In many countries, the quarantine officers own their transportation and are considered traveling officers. Additionally, transportation is available from the units. In all the countries, the officers have access to a telephone.

Some countries have basic fumigation equipment for methyl bromide treatment, but few undertake fumigation. Except for Jamaica, the equipment are not operational. In the Bahamas, fumigation is contracted. Generally, in countries where no fumigation is done, if methyl bromide fumigation is a condition for entry, importers have the option to re-export, contact a pest control operator or have the consignment destroyed. Nevertheless it is difficult to evaluate the need for fumigation as there are inadequate statistics or reporting of interception in the countries. All countries carry out other treatments.

2.3.1.4 Laboratory — In most countries, there is a plant protection diagnostic laboratory located either in the Ministry of Agriculture or in a commodity association. In Jamaica, Barbados, Trinidad, and the Dominican Republic, in addition to the Ministry of Agriculture, a plant protection laboratory is present at the University located on the island and is available to the country. All the laboratories are equipped with the basic equipment for pest diagnosis.

Recently, efforts are being made to establish a network of laboratories from which diagnostic support can be obtained. A survey has been conducted and centers of excellence have been established.

2.3.2 Funding (Table 6)

In all countries, government supplies funds for operation and maintenance of the plant health service. In most cases, this amount is insufficient to support the activities and requirements for plant protection and quarantine services.

Some countries charge fees for issuing of import permits and phytosanitary certificates. In many cases, these fees are only for the certificate and not for the service. Most countries do not charge fees for the performance of other plant quarantine duties. Recently with the advent of the Pink Hibiscus Mealybug (PHMB), Barbados has instituted a preclearance program for infested countries whereby the private sector (exporters) in PHMB countries absorbs the expenses of the visit of the Barbados Quarantine Officer.

2.3.3 Human Resources

2.3.3.1 Network of Specialists — Most countries have specialized personnel in one or more of the plant health disciplines to address plant health issues and to provide adequate and timely scientific input. However, that capability varies considerably depending on the country (Table 7). Additionally, there is access to international institutions where assistance is provided on pest diagnosis and control. University personnel in the countries are available to assist but some indicate that routine diagnosis would be difficult. The

Caribbean Loop of Bionet International (CARINET) provides biosystemics support to the countries as required through the Centre for Agriculture and Biosciences International (CAB-I) group of institutions. However, some countries have complained about the high cost of pest identifications and the speed at which these identifications are made. Recently pest identification training programs on pests of concern have been organized through CARINET. Two such programs have been undertaken for mealybugs and whiteflies.

Most of the countries consider the number and level of training of quarantine staff inadequate (Table 6). Jamaica, St. Lucia, and St. Vincent and the Grenadines have all their staff trained in quarantine at the Diploma or Certificate levels, whilst most of the staff in the other countries were trained by in-service training. However, except for Antigua and Barbuda, the majority had over five years experience.

Staff at the supervisory level in all the countries is trained and has experience in plant health discipline. Many persons have received training at the USDA Animal and Plant Health Inspection Service (APHIS) Training Center at Maryland, United States of America (USA). Additionally, IICA together with other regional and international organizations have provided in-service training courses in plant quarantine for front-line officers. Additionally, public awareness programs are being conducted annually in some countries to sensitize the public and related target groups in order to solicit their support for plant health decisions.

2.3.3.2 Working Relationships with other Port Agencies — Generally, there is good working relationship with the agencies (customs, port authority, shipping agencies) operating at the ports of entry. Plant Quarantine Officers have access to all port areas of quarantine concern. Customs officers and port authority personnel are included in selected quarantine in-service training in many countries and the quarantine service is invited to participate in customs training. This relationship is very important because of the number of ports (official and unofficial) in the countries. As a result, the support of the various port agencies is very important.

The countries are heavily dependent on tourism but there is a weak link between quarantine and the tourism industry. Therefore, monitoring of the tourist in particular and regular passengers in general is inadequate. Through their public awareness programs the countries have been able to encourage closer linkage with the public and shipping agents.

3.0 Implications

All the legislation in the countries except Trinidad was passed before the approval of the SPS Measures or the Revised IPPC Convention. Therefore the initiative in the Caribbean to update their legislation and harmonize it to meet the requirements of WTO (SPS) Agreement is in keeping with international standards.

The countries have been notifying each other through FAO or IICA Plant Health Report, however, the information is not always regular or timely and may not necessarily be accurate. Since pest risk analyses are not recorded, there is no guarantee that decisions are based on scientific evidence. Although national enquiry

points may be in place not many countries are aware of the responsibilities. Sometimes risk management decisions taken may not be in keeping with international standards. For example, because of inadequate resources, a zero risk policy may be taken without examining the options.

The issues of the management of international garbage especially from yachts and cruise ships are of the tremendous concern.

Exporting countries must document national pest status with concrete data so that importing countries can have confidence in the data. The resources available in some of the countries make this activity very difficult. Surveillance information is also important in order to detect the presence of exotic pest early. A plan should be in place for early response to these exotic pests. Written plans for specific pests have not been developed even though there are pests threatening the region or specific countries.

In order to conduct scientific surveys of pest, countries must have access to quality diagnostic laboratories. Nationally, this capability is not available in many countries and assistance has to be obtained elsewhere. This is sometimes a problem when speed in obtaining a response is crucial. There may be need to examine the network of laboratories developed under CARINET more closely.

Governments are funding most of the services provided in the plant health system in the countries. The countries will need to solicit the participation of the private sector in the funding of some of these services thus subsidizing the governments' allocations and providing more resources for activities.

4.0 Conclusion

The countries' capabilities in most cases are very weak thus the ability to meet the requirements of the SPS agreement is low. There is need for a considerable amount of assistance. It must also be remembered that under such conditions, countries are unable to protect themselves and their trading partners efficiently. Therefore, the United States should look towards protecting the Caribbean, its trading partners, in its efforts to protect U.S. Agriculture.

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Plant Protection Act CARICOM Countries.

Table 1. Caribbean Countries Legislation

Country	Plant Quarantine Law	Plant Quarantine Regulations
Antigua and Barbuda	1941	Y
Bahamas	1916	Y
Barbados	1995	Y
Dominica	1986 *	Y
Dominican Republic	1958	N
Grenada	1986 *	Y
Guyana	1942	Y
Haiti	1973	N
Jamaica	1993	N/A
St Kitts and Nevis	1932	Y
Saint Lucia	1988 *	Y
St Vincent and the Grenadines	1941	Y
Suriname	1965	N
Trinidad and Tobago	1997	N/A

* Plant Protection Service

Key: N — None
Y — Yes
N/A — Not available

Table 3. Established WTO SPS Enquiry Points

Country	Enquiry Points (September 1997)
Antigua and Barbuda	N
Bahamas	N
Barbados	Y
Dominica	Y
Dominican Republic	Y
Grenada	N
Guyana	(Identified but not functional)
Haiti	N
Jamaica	Y
St Kitts and Nevis	N
Saint Lucia	N
St Vincent and the Grenadines	Y
Suriname	N/A
Trinidad and Tobago	Y

Key: Y — Yes
N — No
N/A — Not available

Table 2. Internal Operations

Country	Pest List	Pest Reference Collection (Entomology)	Emergency Action Plan	Pest Risk Analysis Unit	Pest Surveillance
Antigua and Barbuda	Y	Y	N	N	R
Bahamas	N	N	N	N	R
Barbados	Y	Y	N	N	R
Dominica	Y	Y	N	N	R
Dominican Republic	Y	Y	N	N	R
Grenada	Y	Y	N	N	R
Guyana	Y	Y [1]	Y	N	R
Haiti	N/A	N/A	N	N	N
Jamaica	Y	Y [1]	N	N/A	R
St Kitts and Nevis	N	N	N	N	R
Saint Lucia	Y	Y	Y	N	R
St Vincent and the Grenadines	Y	Y	N	N	R
Suriname	Y	Y [2]	N	N	R
Trinidad and Tobago	Y	Y [3]	N	N/A	R

1) Also fungi
2) Also fungi and bacteria
3) Also fungi, bacteria and nematodes

Key: Y— Yes
N — None
R — Regular
N/A — Not available

Table 4. Port Operations

Country	Surveillance		Number of Designated Ports	Passenger Declaration Form	Phytosanitary Certificate	Import Permit
	Import	Export				
Antigua and Barbuda	Y	Y	6	N	Y	Y
Bahamas	Y	Y	N/A	N	Y	Y
Barbados	Y	Y	2	N	Y	Y
Dominica	Y	Y	6	N	Y	Y
Dominican Republic	Y	Y	N/A	N	Y	Y
Grenada	Y	Y	N/A	N	Y	Y
Guyana	Y	Y	3	Y	Y	Y
Haiti	Y	Y	N/A	N	Y	Y
Jamaica	Y	Y	6	Y	Y	Y
St Kitts and Nevis	Y	Y	4	N	Y	Y
Saint Lucia	Y	Y	8	N	Y	Y
St Vincent and the Grenadines	Y	Y	12	N	Y	Y
Suriname	Y	Y	3	N	Y	Y
Trinidad and Tobago	Y	Y	5	Y	Y	Y

Key: Y— Yes
N — No
N/A — Not available

Table 5. Facilities

Country	Laboratory Diagnostic	Post Entry Quarantine Facility	Incinerator	Fumigation	Port Office	Transport
Antigua and Barbuda	1	0	None	No	Yes	Yes
Bahamas	0	0	0	No	Yes	Yes
Barbados	2	*	1	Yes	Yes	Yes
Dominica	1	0	1	No	Yes	Yes
Dominican Republic	3	1	1	Yes	Yes	Yes
Grenada	1	0	0	No	Yes	Yes
Guyana	2	**	2	No	Yes	Yes
Haiti	1	0	0	No	Yes	Yes
Jamaica	4	1	2	Yes	Yes	No
St Kitts and Nevis	1	0	1	No	No	Yes
Saint Lucia	2	0	None	No	No	Yes
St Vincent and the Grenadines	1	0	1	No	Yes	Yes
Suriname	2	0	1	No	Yes	Yes
Trinidad and Tobago	2	1	—	(Yes; Not in use)	Yes	Yes

* Intermediate quarantine facility for cocoa
** Sugar cane

Table 6. Funding

Country	Import Inspection	Export Cert.	Diag. Lab. Test
Antigua and Barbuda	N	N	N
Bahamas	N	N	N
Barbados	N	N	Y
Dominica	N	Y	N
Dominican Republic	Y	Y	Y
Grenada	N	N	N
Guyana	N	N	N
Haiti	N/A	N/A	N/A
Jamaica	N/A	Y	Y
St Kitts and Nevis	N	N	N
Saint Lucia	Y	Y	N
St Vincent and the Grenadines	N	Y	N
Suriname	Y	Y	N
Trinidad and Tobago	Y	Y	Y

Key: Y — Yes
N — No
N/A — Not available

Table 7. Human Resource

Country	Graduates in Plant Protection Quarantine [1]	Certificate/ Diploma [2]	Relations with other Agencies
Antigua and Barbuda	2	2/10	Good
Bahamas	N/A	N/A	Good
Barbados	4	2/9	Good
Dominica	3	1/7	Good
Dominican Republic	<40	N/A	Good
Grenada	5	N/A	Good
Guyana	6	2/11	Good
Haiti	N/A	N/A	Good
Jamaica	<30	23	Good
St Kitts and Nevis	2		Good
Saint Lucia		4/4	Good
St Vincent and the Grenadines	3	3/4	Good
Suriname	N/A	N/A	Good
Trinidad and Tobago	<20	N/A	Good

N/A — Not available
1) 1994
2) The second number signifies total

Introduction to the Plant Protection Act of 1999

From the Office of Hon. Charles T. Canady
Representative from Florida's 12th Congressional District
and Chairman, House Judiciary Subcommittee on the Constitution

Note: Find the full text of the this bill through the Government Printing Office (GPO) Web site: http://www.access.gpo.gov/su_docs/legislative.html

Highlights of the Plant Protection Act of 1999

Here are some important provisions contained in the Plant Protection Act:

Higher Penalties for Smuggling — The penalties for Smuggling included in current law are not adequate. For professional smugglers, it is merely the cost of doing business. Under Section 204 of the bill, the monetary penalties for the smuggling of regulated plants, plant pests, and other items will be greatly increased — up to $1,000 for first-time, non-commercial violators; $50,000 for individuals and $250,000 for any other person of violations of a commercial nature; and up to a maximum of $500,000 for all violations adjudicated in a single proceeding. These ne w penalties will provide for real deterrence.

Improved Investigative Power — Current law does not provide APHIS with the tools it needs to effectively investigate violations. Section 203 will provide APHIS with the authority to issue subpoenas in order to secure the testimony and documents needed to investigate any violations resulting in infestations and take appropriate action. All subpoenas would have to meet the test of legal sufficiency, and be reviewed by the USDA's Office of General Counsel prior to issuance.

Transparency — APHIS plant pest interdiction authority is currently scattered among 11 different statutes. This has resulted in substantial confusion among both domestic customers of APHIS and our international trading partners. By consolidating, streamlining, and modernizing these statutes, the legislation will provide a clear, simple, and transparent authority that everyone will be able to understand and comply with.

Progeny — Under current law, APHIS is only able to regulate the original prohibited plant or plant pest, not its offspring. For example, if a

single flower plant that is of a prohibited variety is smuggled or inadvertently brought into the nation, APHIS could only take remedial measures on that single plant, not any clippings or offspring of that plant that have been distributed. Under the Plant Protection Act, APHIS would be able to take appropriate measures to prevent the dissemination of the progeny of the plant in question, as well as the plant itself. This is a much-needed improvement.

Better Procedures at Ports of Entry — Currently, Customs officers at U.S. ports-of-entry are not required to hold prohibited plants or plant pests upon their arrival in the U.S. Consequently, invasive species can enter the country before anyone has had a chance to stop and inspect them. Section 103 would end this problem by requiring Customs officers to hold any such regulated items until APHIS officials have inspected them.

Introduction of the Plant Protection Act of 1999 — H.R. 1504

From the Congressional Record — Extension of Remarks

In the House of Representatives, April 21, 1999 — Hon. Charles Canady of Florida. Mr. Speaker, I rise today to introduce the Plant Protection Act of 1999. Our nation's farmlands, wilderness, and public lands are facing a serious threat from invasive plants and plant pests that can destroy valuable crops and other natural resources. The United States loses thousands of acres and billions of dollars in lost produce and prevention costs each year due to invasion species. In addition, the ecosystems of our parks and wilderness areas are confronting devastating harm from these non-indigenous plants and pests. The rapid growth of international trade has resulted in a vastly increased volume of goods flowing into the country--goods that may carry prohibited foreign plants or noxious weeds.

These harmful invasive plants and species are causing considerable economic damage to natural resources nationwide. In my home state of Florida, Citrus Canker poses the largest threat to citrus crop production in recent history, necessitating over $160 million in state and federal government funding to curb the disease. In the South, cotton producers and the federal government have spent nearly $500 million to prevent damage to crops due to Bollweevil pests. Chicago and New York have suffered significant losses to the Asian longhorned beetle, which has destroyed thousands of trees in city neighborhoods. Noxious weeds have attacked crops in the Carolinas and in the rangelands of Oregon, Idaho and Washington. In California and Florida, invasive species have halted high-value agricultural exports from disease-infested areas. The effect of invasive plants and species throughout the country is profound.

Exacerbating this problem are the outdated, fragmented, and confusing quarantine statutes that govern interdiction of prohibited plant and plant pests. Many of these laws date back to the early part of this century and have not been updated in decades. Our agricultural sector and public lands need a modern, effective statutory authority that will protect our crops from the introduction of harmful pests. The Plant Protection Act of 1999 will build a solid foundation for the future by

streamlining and modernizing plant interdiction laws. This legislation consolidates eleven existing statutes into one comprehensive law and eliminates outdated and ambiguous provisions. It also establishes effective deterrents against trafficking of prohibited species by increasing the monetary penalties for smuggling; providing the U.S. Department of Agriculture with a comprehensive set of investigatory tools; ensuring transparency for U.S. trading partners; and recognizing the benefits of new technologies such as biological control organisms.

The Plant Protection Act, originally introduced in the 105th Congress, will enhance the ability of our nation to protect its lands and crops by giving the Animal and Plant Health Inspection Service the investigatory and enforcement tools it needs. The U.S. Department of Agriculture, as well as 45 agricultural organizations from throughout the country support the Plant Protection Act. I look forward to working with my colleagues to pass this vital and important legislation.

Quarantine and Sanitary Regulations Research Imperatives Panel

Carroll Calkins, Chair
Dorothea Zadig, Ted Batkin, Alberto Pantoja, Ken Vick, Waldemar Klassen

Summary

This panel is assembled to discuss quarantine and sanitary regulations and the research that is needed to make those regulations work in keeping invasive species from entering a designated country. The subjects covered in the following question and answer session included development of a pest data base for each country. This data base would include for each potential species means of identification, life history data, host range, natural enemies, control measures, etc., data on which to act to prevent invasion and/or to eradicate if the pest became established. Education of the public is necessary to illustrate the importance of keeping alien pests out of the respective country. A training system to allow naive individuals the means to identify easily alien and domestic pests must be developed. A rapid expert identification procedure must also be determined for those species difficult to identify.

Errors of host range for some species published in the scientific literature continues to pose a problem for importers. Smuggling of fruit, even when a legitimate pathway is available is also a cause of concern. Finally, someone or some group needs to take the responsibility to make these things happen.

Transcript

In the following transcript, panel members are identified by initials. Audience members are identified where possible.

TB — Ted Batkin
CC — Carroll Calkins
WK — Waldemar Klassen
AP — Alberto Pantoja
KV — Kenneth Vick
DZ — Dorothea Zadig

CC: I'd like to open the discussion on the subject of data bases for potential pest insects. This subject kept coming up throughout this conference, and it seems like this is a very important issue if we're going to get started in trying to protect the various countries or islands from invasions by different pest species. The problem is: Who would be

responsible for those databases and who would maintain them and expand them?

TB: That's the "They" brothers. You know who they are? "They" are going to do it. That's always the problem, it's always the other guy who's responsible for it. And I'm going to ask Waldy if he'd join us up here because this is a question you've dealt with directly and rather than trying to misinterpret what you guys did, I'd like you to take this on and answer some of these questions, especially in this international database area.

WK: There's a lot of interest in databases. There was a workshop held at Las Vegas in November 1998, it was at the joint meeting of the American Phytopathology Society and the Entomological Society of America. The Riley Foundation put out a publication on the various databases that are under development by various organizations. We identified the need for APHIS to have a database, actually, a series of databases with firewalls built in because there is sensitive information that the public shouldn't have. But APHIS should provide data for use by the general public, by international organizations, by universities, and so on. All of that is possible with current technology. It's possible to search multiple databases that are constructed in quite diverse manners. Ron Stinner and Jim Quinn were the experts on this. There's a fairly extensive discussion of that in the report.

AP: A database is needed, but information may not be available in the Caribbean. What is available is information about what's being intercepted in what country. It will help public awareness if they know what's already in the neighborhood. That's a starting point, but at this moment we don't have the information beyond interceptions, and I don't know how to do it or who should do it. We can get information through IICA, or maybe through the U.S. Access to data would help a lot.

TB: I think we're guilty in the U.S. of arrogance; things we think we can do to solve everybody's problem are not available everywhere. Part of any U.S. plan that is going to expand and improve the international database has to understand the limitations in other countries and work with them to overcome those limitations.

Something that was said earlier really struck me. We assume that everybody can just jump on and have access; we have to learn that that's not the case. We have to learn how to walk everywhere before we start running. If anything has come out of this conference, it's that we have to take a couple of steps back and learn how to live with our neighbors.

WK: We had the privilege of meeting with representatives of New Zealand, Australia, and the UK. The New Zealander indicated that they have developed pest lists for 700 commodities, that is, for 700 commodities that are grown in New Zealand, they have lists for all the harmful organisms pertaining to them that occur in New Zealand. Of course, if someone wants to export to them, they provide them with the New Zealand list and ask, "Do you have anything that isn't on our list?" Basically, that's their approach.

The other thing they did — at least they said they did — they have surveyed the entire world literature on all these organisms, and they're willing to share their database with us. But I think that the problem is the quality of the data in different publications varies

extensively. I think that's always going to be a problem for us that we're going to have to check on whether certain things are true or not true, certain records are correct or not correct and so forth. We're going to have to [do more] work on diagnostic techniques than we've done so far.

Aud. [Robert Heath]: With regard to the New Zealand program, the Australians did not disapprove of the program's ambition or scientific purpose, but there were many details that caused misunderstanding and some barriers. For example, the program requires that all Bactrocera (Asian-type tropical flies) in the country be identified as to their hosts. If the United States were to apply that standard to Mexico, it would lead to an endless process. Of the 80-some described species, there's probably 30 with almost nothing known about the host except maybe the ones collected. Another example: *Anastrepha pallas* (?) is found occasionally in Texas, and we've been looking for its host for a long time. We've got one plant, but we frequently trap the fly in places where that plant isn't found.

A lot of preparation should go into a world database before you start erecting barriers to trade and reporting false positives. That would set us back more, than it would advance us.

Aud. [Anthony Belloti]: What Alberto Pantoja was alluding to is referred to in Latin America as the "gray literature." We've attempted to do this. For example for whiteflies, we tried to gather all the gray literature, especially in the Americas, and a CD-ROM is about to come out on that. There's a lot of this information; the problem is access. Students are a good way of doing it. We hired a couple of students to do this over the period of about a year or so.

Also, there are several of these compendia out there on CD-ROM. CATI has one that's quite good, and I just saw one at FAO that's also quite good. The one at CATI is almost free. I don't see why something like this couldn't easily be done for invasive pests. The information is already there, and it would just take some type of grant to get somebody working to pull together information.

AP: I want to comment on the use of lists. When I was in Colombia in 1989 at CIAT, they had lists of rice pests. Colombia claimed there were a hundred or more in Latin America and the Caribbean basin. We went through the list and threw out anything that was not technically demonstrated. We found out there's a lot of information in Latin America; it's found in various libraries all over the region, and it's the basis of the best information in the countries.

When we finished up with the list, there were only five pests of rice in all of Latin America. There's more work like that to be done. We can do technically, but I don't know exactly how to get it done practically. That's one reason that there should be a center for training so we can begin to make a change, and that's a small step. There's a lot of information out there, but somehow someway we have to get it together and make it available.

KV: ARS is always interested in making our expertise available to a wider audience. If we have exotic pests in the Caribbean that are threatening the U.S., that gives us ample justification for helping solve problems of identification. I would be very interested in ideas on how we might play a bigger role with

this scarce expertise. We have a definite interest in keeping pests out of the Caribbean, because they get into the Caribbean Islands and eventually come to the U.S.

DZ: We've found that the video imaging system is one of the answers because there are scarce resources in terms of taxonomy expertise, but the video imaging allows rapid access. Because as all the sources are connected electronically, information moves quickly and the answer comes back when it is still useful.

Aud.: We're beginning to touch on a few things which are going to be bigger than any one of us. We're talking about data systems and the transfer of specialized information to people who need it such as the identification of invasive weeds and insects and diseases and so on. Maybe we need to identify groups in the Caribbean, such as IICA, and ask them if they will champion these different areas to proceed forward. So we can begin to supply that information to the Caribbean. There's a wealth of information here in the U.S.

Another subject that's been mentioned is fungi. Even USDA and University of Florida are saying they have problems with fungi. There are agencies that have some money that we can identify to the Caribbean countries or to foreign universities. FAO comes to mind, and FAS has funds for looking into different aspects of trade and food quality and food health.

Aud.: APS already has a compendium series on plant disease. It's a long-established series, and many tropical crops are covered. It's not all-encompassing, but it is inexpensive at $37 a volume. They are full of color plates that show symptoms that are often diagnostic for a particular disease. I hope USDA and others in the Caribbean have at least a partial set of that series. That would help diagnose a lot of the disease that threaten the islands and Florida also.

A print publication is a starting point, and many diagnosticians I know think CD-ROM is great, but having something right in your hand that you can open up and turn to a picture is most in demand and most user-friendly. We live in an electronic age, and in the U.S. we have access, but a lot of our colleagues south of here don't have these capabilities. Think about all end-users and how they access this information.

Aud. [Keanya Francis]: My name is Keanya Francis and I'm from the Bermuda Zoological Society. I'm not a plant quarantine specialist but I have worked in a plant quarantine laboratory in Bermuda.

A lot of the customs officers at the airport and also at the docks where the cruise ships come in don't really know terms for identifying certain plants, insects, or whatever. Basically, everything is confiscated. A lot of the stuff that comes in on charter flights from, say, Jamaica is confiscated. We sift through it and decide what should be returned to the public. In a small country, you can do things like that. I don't know if it's feasible in a bigger country to confiscate large volumes of produce. But we're able to do it, and it works pretty good.

Also, we've released a few public announcements that have been picked up by local television stations saying that we know summer is the peak season for travel, where people go to the Caribbean a lot and pick up foods. These Public Service Announcements say that you should know, if you bring these things back, we're going to confiscate them.

Even if they are peak mangos, we're going to take them. We tell them to eat it all while you're there and enjoy it, and when you come back you won't be harassed by us. And it seems to work pretty good.

TB: I'll address a couple of the public education aspects. Public education is absolutely critical, along with quarantine, to keep people from bringing pests in. Generating a large enough public education program to reach all U.S. travelers is very large, and it takes resources. Resources are the biggest problem. We have the "Don't Pack A Pest" message; that's an excellent message, but it doesn't reach the travelers. So public education in relation to quarantine and keeping pests out has to be given higher profile in the overall strategic plan of exclusion. Public education has to recognized as being just as critical as technology and permitting and all the little things that are done in verticalities.

There has to be an overarching public education component, but it's also going to require cooperation with the Caribbean nations as well as the nations in the Pacific basin; we're at risk on both sides of the continent. One country can't do this, it has to be a cooperative effort with everyone. I appreciate what you [Keanya Francis] are doing in your area, and I think that we need to learn from the smaller programs and how they're done, and expand them onto a macro basis.

Aud. [Keanya Francis]: Regarding the human resource issue: I was wondering if it is possible to use students for some research work that is needed for identification if they are trained in the commodities and their pests. Is it possible to use students from UNI in Jamaica or UWI in Trinidad for those? Or are there internship opportunities for U.S. students?

WK: The committee that I chaired identified that opportunity. We'd like APHIS to see whether they can do that or not. Since we can digitize a lot of these diagnostic characters and send them by E-mail, we should be able to consult experts in countries other than our own. I don't know if that would cause legal problems or other problems for APHIS, but certainly that's technically feasible.

TB: We've started a program in the citrus industry for pest identification that utilizes lesser trained people, less than PhD or masters level students. We're putting together a package for identification of citrus pests, not only pests in the United States, but citrus pests that occur internationally . It's a pilot program being put together by a professor at Cal Poly San Luis Obispo. The object is to assemble a CD-ROM package that would allow pest identification to be done by relatively low level students, such as junior college students. I tested it on three of my staff who were not entomologists. They were able to take the pilot CD-ROM program to the field and accurately identify pests that they had never seen before. There is tremendous potential with adequate preparation to utilize students anywhere worldwide using this technology, this digitized technology.

Aud. [Mary Jo Hayes]: This is an area I am getting more interested in. I work with Ag in the Classroom; that's part of USDA. The approach is to bring teachers together for an intensive workshop. Then they go back and teach the children. We make it interesting and very knowledgeable, so they go back feeling very competent.

It seems to me we're talking about possibly the same approach in many of these islands where they need information. You don't need to bring every single inspector. Train one educational coordinator who becomes highly competent, and then goes back to train others.

Also, Ag in the Classroom sends out regular updating newsletters to keep people focused, interested, and motivated on the subject and to maintain a continuous information stream. It's very effective and pulls a whole school into focus, not just the one teacher that came up. Maybe this same approach would be useful on a country by country basis, rather than school by school. If I were not trained in entomology, off on a small island and I received this, and I had nobody to say, "Yes, you did it right," I'd have a real serious stress event making a definite decision on what's a pest and what's not. This plan is something we should consider. It is possible for a low input to get a big return.

Aud. [Willie]: I'm an entomologist with PPQ here in Miami, and we've had the video imaging system for a year or so. I've had mine since May, and when I find an insect or a snail or a smaller pest I can't identify in my own lab, I take photos and E-mail them to a specialist in the Washington area, hopefully the Smithsonian, where they have access to the national collection, and I've found that for many taxonomic groups, it's very useful. You get very good IDs from only three or four shots. Other groups, particularly Coleoptera, are very difficult and don't work very well. I and the other entomologists have developed personal picture libraries, diagnostic pictures. As a group, we're already doing IDs for other labs. This hierarchical system could be expanded to countries in the Caribbean. One drawback is that a lot of entomologists are already overworked and more IDs would make things difficult. Also , a lot of the insects we see are routine; we see them over and over. It's the 10% you've never seen before that cause problems, and that's when the video imaging system is really helpful.

AP: Tom mentioned that there's a lot of information available. I wonder how many front line workers know that those CD-ROMs are available? That's a problem. We can get information through IICA or the universities or somehow. Information is available on the Internet, and if we have access probably we have no reason to buy the CD-ROM. But some people don't even know what's available.

Also, I wonder how many CD-ROMs or booklets are available for identifying snails or weeds. I'm talking about living plants to identify them, before they get spread around. That's a problem in the Caribbean. I'm sure someone around there has the information but it's a matter of how we get it together and make it available to national programs. In Puerto Rico, we're getting a lot of seed movement from seed companies, from Argentina for example. We're getting more and more pests from some of those countries. So what's going on out there with seed movement?

Aud.: Ken brought up the issue of misidentification, which happens for insects as well as plant pathogens. What is the protocol to contest whether or not a pathogen or a pest exists in a country? What avenue do they go through to say that, in fact, this pest does not exist here, and you shouldn't legislate against importing a commodity from our area? How does that work?

KV: Very quickly about how you dispute what you might think to be literature citations that are wrong. This is generally done a bilateral case-by-case basis. If there's a citation that's keeping a product out of the U.S., the plant health organization in that country should bring the mistake to the attention of USDA, provide whatever evidence they have to justify their position, and a decision will be made. You can request meetings and sit down face-to-face and work out the differences. We realize there are mistakes in the literature, a lot of times our regulations are based on what's in the literature. If these citations are wrong, we very often change our policy.

KV: A couple of comments: The American Phytopathological Society compendia are wonderful reference volumes, but a caution: They do contain mistakes. The APS compendia are basically compilations from the literature without any particular review of how good those sources are.

Take the case of tobacco blue mold. The APS compendium lists tomato as a host for tobacco blue mold based on a reference from 1935 that has never been repeated. That listing has kept U.S. tomatoes out of Japan for many years. It was just in the last year or so that we finally won that battle. I've never had a more frustrating experience. Policy was based on one reference in the APS volume; that one reference had big impact. It's very easy for this kind of reference to slip in, and there are so many references in the compendia, no one could ever go in and weed out the bad from the good.

In reference to the taxonomic issue, video imaging is great, but you must have a reference collection to back up the identifications. You must have type material. Probably 95% of the identifications can be done using video imaging or the literature, but at some point you're going to come up against specimens that you have to take to a museum and compare to type material. We must have some provision for the tough ones - to be able to send them to specialists and get a timely identification. It does no good for a quarantine to have an identification come back months after a find. It has to be quick.

KV: About the identification issue: When you say 'send them to the Smithsonian,' basically most of those specimens go to ARS. ARS is responsible for the national collection in an arrangement with the Smithsonian museum. We have a cooperative arrangement with APHIS where our taxonomy specialists do identifications that can't be done at the ports. We do this on an overnight basis - send a specimen in, and we get an ID back within a certain number of hours. If we don't have a specialist; then, the specimens have to go to someone else and that will delay things.

Aud. [Philippe Agostini]: If I may comment on that from the other side. The last time I tried to get something identified in Trinidad, the Ministry of Agriculture sent it to the U.K. - and it took weeks and months - that is traditional from colonial times and links with the University of Reading or one of those. The plant quarantine service in Trinidad, as in most Caribbean countries, is severely underfunded. If they have a specimen they are not familiar with, they certainly don't have the capability to identify it overnight. Some sort of Caribbean network is a good idea, but it should be connected with the U.S. side. Obviously, going across the Atlantic to identify these things really doesn't make any sense. It seems to me that IICA would be the ideal agency. I've seen their involvement in other

programs. They would be very interested to pursue something like, and it really doesn't have to be that expensive.

Another point on the question of funding: Dr. Morris, who worked with the entomologists associated with CATI, was one of the foremost young entomologists in Trinidad. He was quite involved with the pink hibiscus mealy bug program. He called me the other day looking for a job because there is no more funding to keep him employed in his line of work. There are trained people out there. The system has to be Caribbean-wide, and it needs to follow the change from colonial networks to the pattern of trade these days.

Aud. [Peter Follett]: Could we turn back for a second to Ted Batkin? With your program, what were the primary fruits that were being smuggled in?

TB: Lychee, longan, and rambutan, and also mango were illegally brought in. Papayas and guavas. . .

Aud. [Peter Follett]: What countries were the sources for these?

TB: Mangoes are from southern Mexico and Central America. We're not sure about lychee and longan, but probably they're coming from southeast Asia.

Aud. [Peter Follett]: Thailand is suspected.

TB: The classic case that everyone refers to was a shipment of longans that came through the Port of Seattle, to Vancouver, across to New York, and down to Miami. They were caught in Miami, but the source was somewhere in the Pacific Rim area.

Mostly what we would like to hear in the Caribbean areas is: What pest-commodity problems do you have that need new or better quarantine treatments - that the science and technology area can get into? I think we've identified some, but there may be others there that we're not catching with our interdiction programs that are potentially dangerous and are sneaking through the system.

Aud. [Guy Hallman]: When we first began looking into this smuggling issue, we found that a lot of mangoes were going through New York, traded to Canada, then coming back by barge. If there's a market that big, then couldn't the Caribbean or Florida be opening it up for themselves. Whatever it takes to get in, that market is going to be pretty lucrative.

PPQ and USDA have a list of which islands in the Caribbean commodities enter from, and there are a few locations where longan and lychee is grown. But only one, St. Vincent, can enter longan and lychee into the United States with inspection. Apparently, the market has not been fully developed. After working in south Florida for 13 years, I have yet to see the first shipment of those commodities come in. So, there's another commodity that's listed but has never gone into real production as an economic crop.

There are other commodities in the Caribbean that can be produced relatively easily with few pests, but the request to import them has never been made, so they're not found on our books today. I wanted to toss out this issue since there are some Caribbean representatives here who may want to go back and see what the value of those crops are and maybe request USDA to do the risk assessments.

Aud.: There's something missing here. If mangoes in Latin America are such a high value commodity, and we have a quarantine treatment for them already, is there a problem with that treatment? Is it poor quality? If that's the case, then having treatments isn't going to stop smuggling.

TB: A lot of the treatments alter the fruit enough so that the people who know how the untreated fruit tastes are unwilling to pay for it. Papayas, mangoes, both of those fall in that category. So, the charge and the challenge is to continue to work on quarantine treatments that maintain the original integrity of the product. This is an opportunity - something positive rather than negative. It's an opportunity for research and technology development, and that's the primary reason: the heat treatment and the current quarantine treatments alter the product enough to make it economically viable to circumvent the system.

KV: I have a question for the audience. Ted mentioned this in his talk, and it's something I've been wrestling with for several years: How do we get legal pathways for commodities that are high in demand? How do we make it legal to import them so that they aren't smuggled in? The longan, the lychee, the rambutan, and those kind of things. . . What's out in the Caribbean for which we could help provide legal treatment access to the U.S. market? Are there commodities in the Caribbean that would be a high priority that we might target to help develop treatments for so that there would be a legal path for those to come in and prevent smuggling?

Aud.: The costs are expensive. It costs money to fumigate, it costs money to have these commodities put into the location for fumigation, etc. . . . There's a bunch of angles, and when you finish doing all this for a pallet of mangoes, it's going to cost you 200 dollars to fumigate. So now, you add that into the price, and then the shelf-life is lost so you've lost money again.

Aud. [Michael Bauscher]: This is a bit of a digression on the issue of regulation. As researchers, we've seen that the way the regulations are written sometimes leaves room for interpretation on the part of the inspector. We had an example of this recently with some material we wanted to bring in from California. A county inspector read the Florida regulation and made a spot judgement as to actually what it meant. As a result, the breeders could not bring in as "propagative parts," pollen, pollen in flowers, or flowers, and seed. When you talk about seed then everybody got upset. We had E-mail flashing back and forth, and we had a meeting about this.
The point is that the experts need to find a way to expedite materials that are brought in with phytosanitation certificates and all that business. By the time the material gets to the person, it's dead or unusable, and these people are trying to help you in phytosanitation issues or resistance or breeding. These people are impeded by the laws which are supposed to be protecting their industry.

DZ: This is one of the issues of the Plant Protection Act — the ability to deal with one organism according to the risk level. Right now according to federal law, organisms have to be regulated as plant pests when it isn't necessarily appropriate. We'd like to see if this could be corrected as we look toward having a risk-based management strategy. It

used to be that everything was a pest, we weren't as sophisticated as we are now, and our laws need to catch up.

Digressing back again, when Grenada and St. Vincent were first designated fruit fly free and commodities were enterable, there was a lot of interest in longans and other Spondia. The irony is that there is still a great deal of interest in longans, it is a seriously smuggled commodity in California, and yet there's a legal pathway for it. So, there's a real opportunity with Spondia that's not being taken advantage of right now.

Another area that is not being addressed very well is growing certain Old World crops in New World countries. New World fruit flies don't necessarily like them.

AP: Going back to the mango issue, I think that the quarantine allows 700 gram mangoes. Some people claim that up to 35% of mangoes exceed that size, and that means we cannot sell them in the U.S. I don't know if that's the same in Mexico or other places, but that may be a reason they are being smuggled.

Aud.: For Caribbean mangoes, one research problem is that for the two pests of interest - the Caribbean fruit fly and West Indies fruit fly - there's no single laboratory in the United States that is permitted to keep them both. We won't accept mangoes from the islands to test because they might be infested with one or the other. Weslaco can do the West Indian fruit fly and Miami can do the Caribbean fruit fly. Miami used to work on West Indies fruit fly, and probably, we can figure out a way to do it, if the Miami lab and Bob Heath stays amendable to this. But that's a problem.

We have an agreement worked out with Mexico for going up to, I believe, 900 grams on the Mexican Colossal mango, but because of various legal processing, we were past the peak season by the time all the arrangements were final, so it will come around next year. We've done post-harvest quality on Mexican mangoes. We ended up testing the Kitts, the Haydens, and, I believe, even some Big Tommy Atkins, so for the red varieties, we did the phytotox work. It does work; we can kill the flies. The advantage is there's a lot of residual heat as long as you don't hydrocool too soon after the treatment. The mangoes hold heat well enough that the treatment doesn't have to be that much longer. So technically, it's not a problem, it's a regulatory problem of getting the tests done.

Aud. [Guy Hallman]: We basically have the data; we could irradiate mango right now. They'll absorb a dose of about 100 Grays for most of those fruit flies. The data is already in. I guess we just need to decide if we want to improve on that or not.

Aud. [Richard Brown]: I just wanted to make a comment. When we did the Caribbean basin marketing workshop in the 80s, we found a myth out there in the world - and maybe in this room, too - but in the general public and within the Department of Agriculture, that fresh fruits and vegetables are a high value product. The handbook that I left with Dean and Waldy has 15 items in it, and if you look at those, we're talking about the wholesale market price for cucumbers, tomatoes, melons, and a bunch of common ones that average anywhere from 15 cents to 50 cents depending on the items; 15 for watermelon and melons. That is not very much per ton, and if you have to go through and add on a very expensive process for treating it, it becomes unprofitable even though it's easy to bring into this country.

The second thing is it takes a whole chain of circumstances to get the product here.

The other comment I wanted to make was that if the Agriculture Marketing Service has grades and standards for anything produced in the United States, then to import that same species, such as mangoes, it has to conform to the U.S. grades and standards or it can't come in. For example, if you're bringing citrus into this country, you have to have it graded by size or it won't be allowed through customs. That was tried with Dominican grapefruit. The case was mixed sizes and degrees of ripeness. These are some of the other things that we haven't heard much about here, but they are significant economic factors to the industry.

TB: A lot of you have asked us about the availability of the Sanitary report. It will be available on the Web after July first. It's in final formatting right now; the document I have is just a draft document. It'll be available through APHIS and also through the National Plant Board Web site. That's the availability of it. It's not a private document.

The other observation I'd like to make is that a lot of things have come up in the conference. Were they captured? I just have one charge to you all. The "They" brothers aren't going to take care of all these things. I wrote an editorial a while back called, "The Other Guy Died Last Night," that's the other guy who used to take care of everything. He's no longer out there. So if you want the action items to occur that you've heard about here, you have to be willing to engage in making sure that they occur. You can't just walk out of here and think that somebody else is going to take care of it.

CC: We've really had a good, lively discussion today. I think we hit some sore spots and some things that really needed to be brought out into the open and identified some solutions. As Ted has inferred, someone needs to take the lead on these issues.

I'd like to thank all the panel members for the answers they gave today and the issues they discussed.

Appendix A. Conference Schedule

Wednesday, June 16, 1999

8:30 Registration

9:30 Welcome

Opening Talks

9:40 Mike Shannon, APHIS State Plant Health Director, Gainesville
• Challenges in Safeguarding Florida and the U.S. against Invasive Pests

10:00 William A. Messina, Jr., Coordinator of Educ./Training, Food and Resource Economics Department (FRED), University of Florida, Gainesville
• Domestic and International Business Climate

Topic 1. Critical Commodities in the Caribbean Basin: Patterns of Trade and Market Potential

10:50 Richard N. Brown, Jr., formerly USDA-ERS
• Critical Commodities in the Caribbean Basin: Patterns of Trade and Market Potential

11:30 Lunch

Topic 2. Offshore Pests and Pathogens that Threaten Fruit and Vegetable Production in the Caribbean Region

12:30 Daniel A. Fieselmann, Chair PPQ B\national New Pest Advisory Group, Raleigh, NC
• Offshore Pests and Pathogens that Threaten Fruit and Vegetable Production in the Caribbean Region

12:50 Rosa Franqui, UPR
• History of Introduced Pests in Puerto Rico and Potential Introductions

1:10 • Exotic Weeds that Threaten the Caribbean

Keanya Francis, Bermuda Zoological Society
• Management of Invasive Pest Plants in Bermuda — Paradise under Siege: The Susceptibility of Oceanic Islands to Plant Invasion

Richard Moyroud, Mesozoic Landscapes, Inc.
• Exotic Weeds that Threaten the Carribean: A Brief Overview and Early Alarm

Tony Pernas, Big Cypress Preserve
• Exotic Pest Plants in South Florida's Natural Areas

2:00 Greg MacDonald, UF
• Weedy Plant Issues Affecting Tropical Agriculture

2:20 Julio Medal, UF
• Biological Control of Some Exotic Weeds by Means of Pathogens

2:40 Break

3:00 Raghavan Charudattan
• Biological Control of Some Exotic Weeds by Means of Pathogens

3:20 Randy Ploetz
• Exotic Plant Pathogens and the Caribbean Region

3:50 Jorge E. Peña
• Exotic Arthropods and the Caribbean Region

4:20 Offshore Research Imperatives Panel
Chair: Anthony Bellotti Panel Members: C. Calkins, R. Stocker, R. Ploetz, R. Charudattan

4:50 Adjourn

Thursday, June 17, 1999

Topic 3: Offshore Strategies for Reducing or Eliminating the Threat of Exotic Pests and Diseases

8:30 Dale Meyerdirk, APHIS-PPQ
• Pre-emptive Thrust against the Pink Hibiscus Mealy Bug — A Model for Meeting Invasive Pest Threats in the Caribbean

8:50 Elena Gomez
• Preclearance Programs and Pest-free Production Zones in Mexico, Central America and Caribbean Island Nations

9:20 Mary Jo Hayes, FDACS-DPI
• Caribfly-free Zones in Florida to Facilitate Grapefruit Exports to Japan

9:40 Tim Schubert, FDACS-DPI
• Florida's Experience with Citrus Canker

10:00 Break

10:20 Anthony C. Bellotti
• The Role of CIAT in Meeting the Challenge of New Invasive Pests in the Caribbean Region

10:40 Robert Heath
• The Role of the Subtropical Exotic Plant Insect Research Unit at ARS, Miami in Meeting Invasive Pest Problems in the Caribbean Region

Topic 4. Risk Assessments with Respect to Trade within the Caribbean Region

11:00 Ron Sequeira, APHIS-PPQ
• Regulatory Pest Risk Assessments

11:20 Randall Stocker, Center for Aquatic Plants, Univ. of Fla.
• Weed Risk Assessments: The Problem with Predictions

11:40 Lunch

12:40 Offshore Threats Research Imperatives Panel
Chair: Randall Stocker, Panel Members: D. Meyerdirk, M. Hayes, A. Bellotti, R. Heath, R. Sequeira

Topic 5. Market Development Strategies for Caribbean Products

1:10 John VanSickle, Food and Resource Economics Dept, Univ. of Fla.
• Critical Commodities in the Caribbean Basin: Patterns of Trade and Market Potential: A Florida Perspective

1:50 Sergio Oxman, KIEN Consultants, Santiago, Chile
• A Win-Win Trade Situation: The Chilean Experience

2:10 Break

2:40 Philippe Agostini, F.A. Agostini Estates, Ltd, Trinidad
• Market Development Strategies for Caribbean Products

3:00 Economic Research Imperatives Panel
Chair: John VanSickle, Panel Members: R. Brown, S. Oxman, W. Messina, P. Agostini

Topic 6. Quarantine Treatments and Certification of Treatments

3:30 Ken Vick, USDA-ARS
• Developing Quarantine Treatments and Getting Them Approved

3:50 Guy Hallman, USDA-ARS
• Quarantine Treatments: Facilitators of Trade in the Presence of Exotic Pests

4:10 Roy McDonald, USDA-ARS
• Maintaining Post-Harvest Quality

4:30 Peter Follett, USDA-ARS
• Treatments for Non-Fruit-Fly Pests of Quarantine Importance: Problems and Approaches

4:50 Peter Grosser, USDA-APHIS
• Port Operations

5:20 Robert Mangan, USDA-ARS
• Can Pest Management Activities Allow for Alternatives to the "Probit 9" Quarantine Treatment Requirement?

5:30 Adjourn

Friday, June 18, 1999

Topic 7. Challenges in Implementing Sanitary Regulations and Quarantine Practices Generally and in the Caribbean Region

8:30 Dorothea Zadig
• Safeguarding American Plant Resources: Highlights of a Review by the National Plant Board of Relevant APHIS Programs

9:15 Ted Batkin
• Research and Technology Development Thrusts Recommended by the National Plant Board Study on Safeguarding American Plant Resources

9:45 • Alberto Pantoja, UPR
Preliminary Assessment of Training and Technical Assistance Needs of Caribbean Nations in Strengthening Phytosanitary and Quarantine Practices

10:30 Break

10:50 Everton Ambrose, IICA, St. Lucia
• An Assessment of the Plant Health System in the Caribbean

11:10 Karen Williams, Assistant to U.S. Representative Charles Canady (R-FL)
• Safeguarding American Biological Resources against Exotic Invasive Pests

11:30 Lunch

12:15 Quarantine and Sanitary Regulations Research Imperatives Panel
Chair: Carroll Calkins, Panel Members: J. Sharpe, D. Zadig, T. Batkin, A. Pantoja, K. Vick

12:40 Closing Address

Appendix B. Workshop Participants

(Conference presenters/authors are marked with **.)

Philippe Agostini**

F.A. Agostini Estates
PO Bag 254B
Westmoorings, Trinidad

Tel.: (868) 633-8475
Fax: (868) 633-5924
E-mail: agostini@trinidad.net

Divina Amalin

Tropical Research and Education Center, Univ. of Fla.
18905 SW 280 St.
Homestead FL 33031-3314 USA

Tel.: (305) 246-7049
Fax: (305) 246-7003
E-mail: dmam@icon.hmsd.ufl.edu

Everton Ambrose**

IICA
PO Box 1223
Castries, St.Lucia, W.Indies

Tel.: (758) 451-6760
Fax: (758) 451-6774
E-mail: iica@candw.lc

Abdel Bakri

Tropical Research and Education Center, Univ. of Fla.
18905 SW 280 St.
Homestead FL 33031-3314

Tel.: (305) 246-7049
Fax: (305) 246-7003
E-mail: bakri@icon.hmsd.ufl.edu

Carlos Balerdi

UF/ Miami-Dade Coop. Extension
18710 SW 288 Street
Homestead FL 33030

Tel.: (305) 248-3311
Fax: (305) 246-2932
E-mail: cfb@gnv.ifas.ufl.edu

Ted Batkin**

Citrus Research Board
PO Box 230
Visalia CA 93279

Tel.: (559) 738-0246
Fax: (559) 738-0607
E-mail: Tbatkin@lightspeed.net

Michael Bausher

USDA-ARS-USHRL
2120 Camden Rd
Orlando FL 32803

Tel.: (407) 897-7353
Fax: (407) 897-7309
E-mail: mbausher@magicnet.net

Anthony Belloti**

CIAT (International Center for Tropical Agriculture)
CIAT, AA6713
Cali, Columbia

Tel.: (572) 445-0000
Fax: (572) 445-0073
E-mail: a.bellotti@cgiar.org

Ken Bloem

USDA-APHIS-Nat'l Biol. Control Inst.
429 Meadow Ridge Drive
Tallahassee FL 32312

Tel.: (850) 894-2662
Fax: (850) 894-2083
E-mail: ksbloem@nettally.com

Julieta Brambila

Tropical Research and Education Center,
Univ. of Fla.
Homestead FL 33031

Tel.: (305) 246-7041
Fax: (305) 246-7003
E-mail: jbc@gnv.ifas.ufl.edu

Charles Brown

IFAS Educational Media and Services,
Univ. of Fla.
PO Box 110810
Gainesville FL 32611-0810

Tel.: (352) 392-2411
Fax: (352) 392-7902
E-mail: cbrown@gnv.ifas.ufl.edu

Richard Brown, Jr.**

USDA, Ret.
8106 Smithfield Ave.
Springfield VA 22152

Tel.: (703) 451-6116
Fax: ---
E-mail: mapleman@worldnet.att.net

Herb Bryan

Tropical Research and Education Center,
Univ. of Fla.
18905 SW 280 St.
Homestead FL 33031-3314

Tel.: (305) 246-7042
Fax: (305) 246-7003
E-mail: hhb@icon.hmsd.ufl.edu

Carroll Calkins**

USDA-ARS
5230 Konnowac Pass Rd
Wapato WA 98951

Tel.: (509) 454-6550
Fax: (509) 454-5646
E-mail: ccalkins@yarl.gov

John Capinera

Department of Entomology/Nematology,
Univ. of Fla.
PO Box 110620
32611-0620

Tel.: (352) 392-1901
Fax: (352) 392-0190
E-mail: jlcap@gnv.ifas.ufl.edu

Raghavan Charudattan**

Center for Aquatic and Invasive Plants;
Dept. of Plant Pathology, Univ. of Fla.
1453 Fifield Hall
Gainesville FL 32611

Tel.: (352) 392-7240
Fax: (352) 392-6532
E-mail: rc@gnv.ifas.ufl.edu

Dean Davis

T-STAR, Univ. of Fla.
Room 3091 McCarty Hall
Gainesville, Florida 32611

Tel.: (352) 392-7141
Fax: (352) 846-0816
E-mail: dfd@gnv.ifas.ufl.edu

Maria Delgado

Tropical Research and Education Center,
Univ. of Fla.
18905 SW 280 St.

Homestead FL 33031-3314
Tel.: (305) 246-6345
Fax: ---
E-mail: mdelgado@icon.hmsd.ufl.edu

Rita Duncan

Tropical Research and Education Center,
Univ. of Fla.
18905 SW 280 St.
Homestead FL 33031-3314

Tel.: (305) 246-7042
Fax: (305) 246-7003
E-mail: red@icon.hmsd.ufl.edu

Claudia Ferguson

USDA-APHIS-PPQ-Maritime
1600 Port Blvd.
Miami FL 33132

Tel.: (305) 536-4878
Fax: (305) 536-4876
E-mail: ---

Daniel Fieselmann**

USDA-APHIS-PPQ, Raleigh Plant
Protection Center
1017 Main Campus Dr, Ste 2500
Raleigh NC 27606

Tel.: (919) 513-2126
Fax: (919) 513-1995
E-mail: Daniel.A.Fieselmann@usda.gov

Peter Follett**

USDA-ARS
PO Box 4459
Hilo HI 96720

Tel.: (808) 959-4300
Fax: (808) 959-4323
E-mail: follett@aloha.net

Keanya Francis**

Bermuda Zoological Society
PO Box 145
Smiths FL BX Bermuda

Tel.: (441) 293-2727
Fax: ---
E-mail: kfrancis@northrock.bm

Rosa Franqui**

UPR-AES
PO Box 21360
Rio Piedras 00928-1360 Puerto Rico

Tel.: (787) 767-9705
Fax: (787) 765-5158
E-mail: r_franqui@yahoo.com

Juan Galera

USDA
PO Box 37521 Airport Station
San Juan 00937-0521

Tel.: (787) 253-7851
Fax: (787) 253-4514
E-mail: Juan.R.Galera@usda.gov

Helena Gomez**

USDA-APHIS-IS
USAID Bldg-Haiti, 17, Harry Truman Blvd.
Haiti

Tel.: (509) 222-5500
Fax: (509) 223-9603
E-mail: hgomez@usaid.gov

Celso Goseco

Del Monte Fresh Produce
PO Box 149222
Coral Gables 33114

Tel.: (305) 520-8101
Fax: (305) 445-7612
E-mail: cgoseco@freshdelmonte.com

Walter Gould

USDA-ARS
13601 Old Cutler Rd.
Miami FL 33158

Tel.: (305) 238-9321
Fax: (305) 238-9330
E-mail: miawg@ars-grin.gov

Gary Greene

USDA/APHIS-Puerto Rico
IBM Bldg-Ste 700, 654 Munoz Rivera Ave
Hato Rey PR 00918

Tel.: (787) 771-3611
Fax: (787) 771-3613
E-mail: gary.t.greene@usda.gov

Peter Grosser**

USDA-APHIS-PPQ
4700 River Rd. Unit 140
Riverdale MD 20737-1236

Tel.: (301) 734-6799
Fax: (301) 734-5786
E-mail: Peter.M.Grosser@usda.gov

Guy Hallman**

USDA-ARS
2301 S. International Blvd.
Weslaco TX

Tel.: ---
Fax: ---
E-mail: hallman@POP.TAMU.EDU

Mary Jo Hayes (no paper)**

FDACS-DPI
PO Box 147100
Gainesville FL 32614-7100

Tel.: (352) 372-3505
Fax: (352) 372-2301
E-mail: hayesmj@doacs.state.fl.us

Robert Heath

USDA-ARS
13601 Old Cutler Rd.
Miami FL 33158

Tel.: ---
Fax: ---
E-mail: Bheath@gainesville.usda.ufl.edu

Leslie Herren

19900 SW 264 St.
Homestead FL 33031)

Tel.: (305) 247-2470
E-mail: azas@sprynet.com

Paul Hornby

USDA-APHIS-PPQ
7022 NW 10 Place
32605

Tel.: (352) 331-3990
Fax: (352) 331-0804
E-mail: paul.l.hornby@usda.gov

William Jones

PO Box 8119
St. Thomas 00801 Virgin Islands

Tel.: (340) 776-2787
Fax: ---
E-mail: gecell@yahoo.com

Waldemar Klassen**

Tropical Research and Education Center,
Univ. of Fla.
18905 SW 280 St.
Homestead FL 33031-3314

Tel.: (305) 246-7038
Fax: (305) 246-7003
E-mail: klassen@icon.hmsd.ufl.edu

Elaine Klema

Tropical Research and Education Center,
Univ. of Fla.
18905 SW 280 St.
Homestead FL 33031-3314

Tel.: (305) 246-7049
Fax: (305) 246-7003
E-mail:

Greg MacDonald**

Dept. of Agronomy, Univ. of Fla.
PO Box 110500
Gainesville FL 32611-0500

Tel.: (352) 392-6196
Fax: (352) 392-1840
E-mail: gemac@gnv.ifas.ufl.edu

Robert Mangan**

USDA-ARS
2301 S. International Blvd.
Welasco TX 78596

Tel.: (956) 565-2641
Fax: (956) 565-6652
E-mail: ---

Roy McDonald**

Dept. of Horticultural Sciences, Univ. of Fla.
2120 Camden Rd
Orlando FL 32803-1419

Tel.: (407) 897-7324
Fax: (407) 897-7300
E-mail: ---

Terry McGovern

4951b East Adamo Drive, Ste 220
Tampa FL 33605

Tel.: (813) 228-2121
Fax: (813) 228-2441
E-mail: terry.e.mcgovern@usda.gov

Ray McGuire

USDA-ARS
13601 Old Cutler Rd.
Miami FL 33158

Tel.: (305) 254-3641
Fax: ---
E-mail: ---

Cindy McKenzie

USDA-US Hort. Research Lab
2199 S. Rock Rd.
Ft. Pierce 34945

Tel.: (561) 461-4759
Fax: (561) 461-9565
E-mail: cindylmckenzie@msn.com

Robert T. McMillan

Tropical Research and Education Center, Univ. of Fla.
18905 SW 280 St
Homestead FL 33031-3314

Tel.: (305) 246-7000
Fax: (305) 246-7003
E-mail: rtmcm@icon.hmsd.ufl.edu

Julio Medal**

Dept. of Entomology/Nematology, Univ. of Fla.
PO Box 110620
Gainesville FL 32611-0620

Tel.: (352) 392-1901
Fax: ---
E-mail: medal@gnv.ifas.ufl.edu

William A. Messina, Jr.**

Dept. of Food and Resource Economics, Univ. of Fla.
PO Box 110240
Gainesville FL 32611-0240

Tel.: (352) 392-1881, ext. 308
Fax: (352) 392-9898
E-mail: messina@fred.ifas.ufl.edu

Wendy Meyer

Tropical Research and Education Center, Univ. of Fla.
18905 SW 280 St.
Homestead FL 33031

Tel.: ---
Fax: ---
E-mail: wlme@icon.hmsd.ufl.edu

Dale Meyerdirk**

APHIS-PPQ-Nat'l Biol. Control Inst.
4700 River Rd., Unit 135
Riverdale MD 20737-1229

Tel.: (301) 734-8192
Fax: ---
E-mail: Dale.E.Meyerdirk@USDA.GOV

Mary Misitis

UF/Miami-Dade Coop. Extension
18710 SW 288 Street
Homestead FL 33030-2309

Tel.: (305) 248-3311
Fax: (304) 246-2932
E-mail: ---

Richard Moyroud*

Moyroud Mesozoic Landscapes, Inc.
7667 Park Lane W
Lake Worth FL 33467

Tel.: (561) 967-2630
Fax: (561) 276-8102
E-mail: RNVX54A@prodigy.com

John T. Neilson

College of Veterinary Medicine, Univ. of Fla.
PO Box 110880
Gainesville FL 32611-0880

Tel.: (352) 392-4700
Fax: (352) 392-9704
E-mail: NeilsonJ@mail.vetmed.ufl.edu

Leland Newport

USDA-APHIS-PPQ
7022 NW Place
Gainesville FL 32605-3147

Tel.: (352) 331-3990
Fax: (352) 331-0804
E-mail: lee.newport@usda.gov

Teresa Olczyk

UF/Miami-Dade Coop Extension
18710 SW 288 Street
Homestead FL 33030-2309

Tel.: (305) 248-3311
Fax: (304) 246-2932
E-mail: ---

Sergio Oxman**

KIEN Consultants
Nueva York 52, Suite 511
Santiago Chile

Tel.: (562) 699-5325
Fax: (562) 699-5323
E-mail: soxman@interactiva.cl

Alberto Pantoja**

UPR&Recinto Univ. de Mayaguez
Apt. 9030
Mayaguez PR 00681-9030

Tel.: (787) 832-4040
Fax: (787) 265-3853
E-mail: a_pantoja@rumac.upr.clu.edu

Jorge Peña**

Tropical Research and Education Center, Univ. of Fla.
18905 SW 280 St.
Homestead FL 33030-3314

Tel.: (305) 246-7048
Fax: (305) 246-7003
E-mail: jepe@icon.hmsd.ufl.edu

Tony Pernas**

Everglades National Park
40001 SR 9336
Homestead, Fl 33034

Tel.: (305)242-7846
Fax: (305)242-7836
E-mail: Tony_Pernas@nps.gov

Randy Ploetz**

Tropical Research and Education Center, Univ. of Fla.
18905 SW 280 St.
Homestead FL 33031-3314

Tel.: (305) 246-7005
Fax: (305) 246-7003
E-mail: rcp@icon.hmsd.ufl.edu

Don Pybas

Miami-Dade Coop. Extension, Univ. of Fla.
18710 SW 288 St.
Homestead FL 33030-2309

Tel.: (305) 248-3311, ext.241
Fax: (305) 246-2932
E-mail: pybas@gnv.ifas.ufl.edu

Adalton Raga

TREC/Instituto Biologico
Rodovia Heitor Penteado Km 35 CP 70
Sao Paulo Campinas 13001- 097 Brazil

Tel.: ---
Fax: ---
E-mail: adalton11@hotmail.com

Norma Rosario

USDA-APHIS-Puerto Rico
IBM Bldg-Ste 700, 654 Munoz Rivera Ave
Hato Rey PR 00918

Tel.: (787) 771-3611
Fax: (787) 771-3613
E-mail: ---

Jennifer Rousseau

FAS-Caribbean Basin Ag Trade Office
909 SE 1st Ave., Ste 720
Miami FL 33131

Tel.: (305) 536-5300
Fax: ---
E-mail: chato@ibm.net

Timothy S. Schubert**

FDAC-DPI
1911 SW 34 St.
Gainesville, FL 32608-1268

Tel.: (352) 372-3505
Fax: ---
E-mail: schubet@doacs.state.fl.us

Henry Schuster

Dept. of Agriculture
#1 Estate Lower Love
St. Croix 00850

Tel.: (340) 778-0991
Fax: (304) 778-7977
E-mail: pmcb20@islands.vi

Nelson Semidey

Crop Protection Department
P.O. Box 9030
Univ. of Puerto Rico, Mayagüez Campus
Mayagüez PR 00681-9030

Tel.: (787) 265-3859
Fax: ---
E-mail: N_Semidey@Rumac.upr.clu.edu

Ron Sequeira**

APHIS-PPQ
1017 Main Campus Dr., Ste 2500
Raleigh NC 27606 USA

Tel.: (919) 513-2126
Fax: (919) 513-1995
E-mail: ---

Michael J. Shannon**

USDA-APHIS-PPQ
7022 NW 10 Place
Gainesville FL 32605-3147

Tel.: (352) 331-3990
Fax: (352) 331-0804
E-mail: Mike.Shannon@usda.gov

Brian Sheahan

Tropical Research and Education Center,
Univ. of Fla.
18905 SW 280 St.
Homestead FL 33031-3314

Tel.: (305) 246-6344
Fax: (305) 246-7003
E-mail: bts@gnv.ifas.ufl.edu

Bill Sherrod

SWFREC
2686 State Road 29 N
Immokalee 31429-0000

Tel.: (941) 658-3400
Fax: ---
E-mail: whsh@icon.imok.ufl.edu

Randall Stocker**

Center for Aquatic and Invasive Plants,
Univ. of Fla.
PO Box 110610
Gainesville FL 32611-0610

Tel.: (352) 392-9613
Fax: (352) 392-3462
E-mail: aqplants@gnv.ifas.ufl.edu

Stewart Swanson

Brooks Tropicals
PO Box 900160
33090-0160

Tel.: (305) 247-3544
Fax: (305) 245-8023
E-mail: stewart@brookstropicals.com

William Tang

USDA-APHIS-PPQ
1790 Port Blvd.
Miami FL 33132

Tel.: (305) 536-4758
Fax: (305) 536-4462
E-mail:

Marie Thorp

Tropical Research and Education Center,
Univ. of Fla.
18905 SW 280 St.
Homestead FL 33031-3314

Tel.: (305) 246-7037
Fax: (305) 246-7003
E-mail: meth@icon.hmsd.ufl.edu

Harry J. Trafford

Tropical Research and Education Center,
Univ. of Fla.
18905 SW 280 St.
Homestead FL 33030

Tel.: (305) 246-7026
Fax: (305) 246-7003
E-mail: traff@icon.hmsd.ufl.edu

John J. VanSickle**

Dept. of Food and Resource Economics,
Univ. of Fla.
PO Box 110240
32611-0240

Tel.: (352) 392-2297
Fax: (352) 846-0988
E-mail: vansickle@fred.ifas.ufl.edu

Kenneth W. Vick**

USDA-ARS
5601 Sunnyside Avenue
Beltsville MD 20705-5139

Tel.: (301) 504-5321
Fax: (301) 504-5987
E-mail: kwv@ars.usda.gov

Ian Wedderspoon

Ian Industries, Inc.
13015 SW 89 Pl, Suite 203
Miami FL 33176

Tel.: (305) 255-6706
Fax: (305) 255-1317
E-mail: ---

Craig Wheeling

Brooks Tropicals
PO Box 900160
Homestead FL 33090-0160

Tel.: ---
Fax: ---
E-mail: ---

Dorthea Zadig**

DOA-DPI
PO Box 942871
Sacramento CA 94271-0001

Tel.: (916) 653-1440
Fax: ---
E-mail: Dzadig@smtp1.cdfa.ca.gov

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